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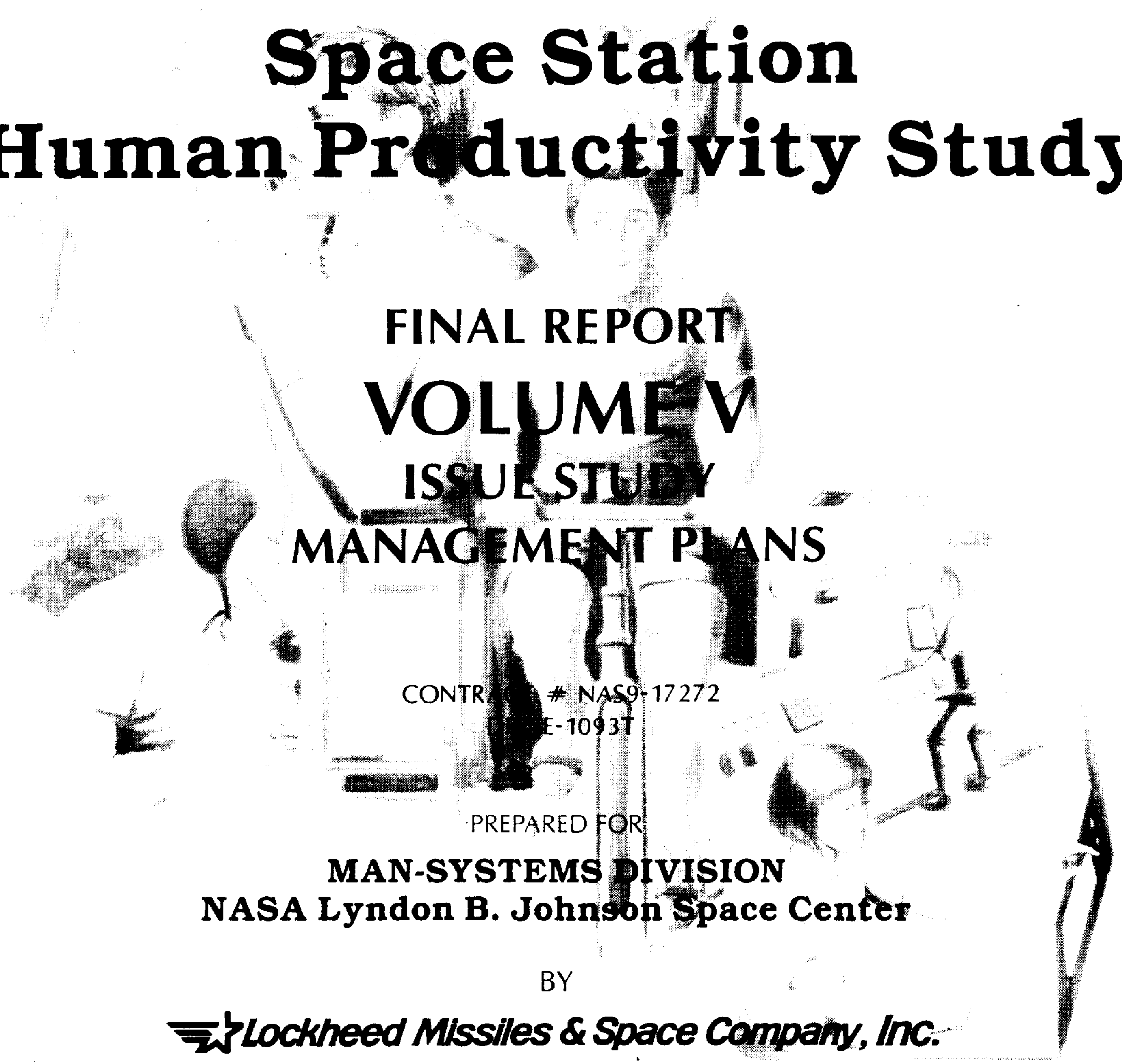

Space Station Human Productivity Study

FINAL REPORT
VOLUME V
ISSUE STUDY MANAGEMENT PLANS

CONTRACT # NAS9-17272
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PREPARED FOR

MAN-SYSTEMS DIVISION
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INTRODUCTION

The 67 Management Plans in this volume represent recommended study approaches for resolving 108 of the 305 Issues which were identified during the Human Productivity Study. The process of Issues selection for preparation of these plans and a full description of the Management Plan rationale are described in Volume I of the Final Report. Each study Management Plan is prepared in three formats:

Format 13:	Management Plan Overview Lists the subsumed Issues, study background and related overview information.
Format 14:	Study Plan Details the study approach by tasks, lists special needs, and describes expected study products.
Format 15:	Schedule-Task Flow Provides a time-lined schedule for the study tasks and resource requirements.

The recommended schedules were driven by the following objectives:

- o Schedule the completion of each study so that requirements can be defined for timely inputs to the Space Station Program (SSP).
- o Relate schedules to a common set of SSP Milestone dates, as listed under the System Level Critical Assumptions. (As of May 1985; See Volumes I, II, or III)
- o Assume an earliest study start date of 1 October 1985.
- o Assume that all data or resources will be available as noted.

Please refer to Volume I, Task 6 and Recommendations, concerning the need to integrate and revise presently shown schedules.

One tool for performing the schedule integration task is the Management Plan Relationships matrix, included in this volume. The matrix shows the data input-output relationships among all recommended studies. A listing is also included which cross-references the Unresolved Requirements to Issues to Management Plans. Immediately following this introduction is a list of the Management Plans and their subsumed Issues. Finally, a Glossary of all abbreviations utilized throughout the study is provided for the reader.

The complete set of volumes for the Human Productivity Final Report consists of:

Volume I	-	Final Report (Study Description)
Volume II	-	Executive Summary (and Oral Review)
Volume III	-	Requirements
Volume IV	-	Issues
---> Volume V	-	Management Plans

LIST OF MANAGEMENT PLANS

MGMT PLAN NO.	ISSUE NO.	TITLE
101M01		COMPARTMENT ARRANGEMENT & VOLUME GUIDELINES
	1010201	Minimum Activity Area Volume Requirements
	1010401	Multi-use vs. Dedicated Space Criteria
	1010701	Compartment/Area Adjacency Criteria
	1010801	Module/Activity Area Orientation Standard
102M01		TRAFFIC FREQUENCY & WORKSTATION LOCATION
	1020101	Traffic Frequency Determination
	1020301	Workstation Locations Criteria
103M01		INTERIOR DESIGN GUIDELINES
	1030101	Interior Design Guidelines
	1030201	Interior Design Modifiability Provisions
	1030301	Color, Label, and Pattern Coding Criteria
103M02	1030302	INTERIOR LOCATION COORDINATE SYSTEM
104M01	1040001	HAB INTERIOR MATERIALS SELECTION REQUIREMENTS
105M01		ANTHROPOMETRIC DATA DEVELOPMENT
	1050201	Anthropometric Range
	1050301	Neutral Body Posture Data Development
	1050401	Growth and Anthropometric Criteria
106M01	1060101	INTERIOR VOLUME REARRANGEMENT RQMTS
106M02	1060102	STANDARD HARDWARE AND INTERFACE RQMTS
109M01		EQUIPMENT & FOOD STOWAGE; IOC & GROWTH
	1090101	Stowage Configuration
	1090601	Stowage Volume & Configuration for Growth
109M02	1090401	DATA FILE STOWAGE REQUIREMENTS
109M03	1090301	TRASH-WASTE STOWAGE AND STORAGE
201M01	2010101	ATMOSPHERE SPECIFICATION
201M03	2010202	MAINTAIN/TEST POTABLE WATER PURITY
201M04	2010203	WATER ALLOCATION FOR CREW SUPPORT
201M05		CONTAMINATION: LIMITS & GASEOUS LOAD MODEL
	2010301	Gaseous Contaminant Load Model
	2010302	Microbial Load Model
201M06	2010303	CONTAMINATION LIMITS
202M01		RADIATION MONITORING SYSTEM
	2020101	Radiation Monitoring System
	2020102	Personnel Dosimitry
202M02		SHIELDING PROTECTION
	2020103	Optimal Shielding Distribution
	2020104	Window Radiation Protection
	2020105	Shielded Storage
	2020801	Micrometeorite and Debris Protection
	2021001	Radiation Shielding Strategy for Growth

LIST OF MANAGEMENT PLANS

MGMT PLAN NO.	ISSUE NO.	TITLE
202M03		SOLAR FLARE PROTECTION
	2020502	Solar Flare Protection
	2020501	Solar Flare Risk
	2020503	Solar Flare Contingency Planning
	2020504	Solar Flare Warning System
202M04	2020401	HZE PARTICLE PROTECTION FEASIBILITY
202M05	2021201	GROUND SUPPORT FOR RADIATION PROTECTION
202M06	2020106	RADIATION AWARENESS TRAINING
203M01		INDUCED ENVIRONMENT PROTECTION
	2030201	EM Leakage Specifications
	2030202	RF/Microwave Exposure Levels
	2030401	Laser Light Protection Options
	2030501	Synergistic Induced Environ Effects
204M01	2040101	PHYSIOLOGICAL EFFECTS OF LIGHT
205M01	2050101	PREDICTION OF LOW FREQUENCY NOISE
205M02	2050102	LOW FREQUENCY NOISE CONTROL
205M03	2050201	LONG DURATION 0-G NOISE EXPOSURE LIMITS
207M01	2070104	ZERO-G SPORTS AND GAMES
207M02	2070301	ANIMAL PAYLOAD BIOISOLATION
207M03		TASK PERFORMANCE ASSESSMENT
	2070401	Zero-G Visual Perf. Criteria
	2070402	Critical Task Perf. Assessment
209M01		ZERO-G RECREATION
	2090101	Individual Recreational Preferences
	2090102	0-G Rec. Activities, Equipment, and Matls
	2090201	Facility for Group Recreation
	2090202	Facility for Individualized Recreation
	2090301	Off-Shelf Recreational Equipment Feasibility
	2090302	Innovative Recreational Provisions
	2090501	Recreation Objectives
211M01	2110801	POTABLE WATER
212M01		HOUSEKEEPING ITEMS AND EQUIPMENT
	2120201	Cleaning Materials
	2120202	Housekeeping Equipment
	2120701	Housekeeping Equipment - Growth
213M01	2130202	WASTE AND TRASH COLLECTION METHODS
213M02	2130701	CONTINGENCY TRASH DISPOSAL METHODS
213M03	2130101	WASTE TRASH GENERATION MODEL
213M05	2130501	WASTE/TRASH EQUIPMENT TRANSFER
213M06	2130601	TRASH COMPACTOR REQUIREMENTS
214M02	2140102	MODULE DOCKING AIDES

LIST OF MANAGEMENT PLANS

MGMT PLAN NO.	ISSUE NO.	TITLE
214M03	2140201	INVENTORY MANAGEMENT SYSTEM DEVELOPMENT
215M01		RESTRAINTS
	2150101	Standardized Footwear/Foot Restraint System
	2150301	Cable and Hose Management System
	2150302	Equipment Restraints
	2150201	Body Restraints
	2150501	Crew Portable Restraint System
216M01		EQUIPMENT RESTRAINT & TRANSFER
	2160201	Containment & Translation of Equipment
	2160101	Crew Translation Aids
	2160102	Inadvertent Impact Protection
218M01	2180601	ON-ORBIT CONFIGURATION MODS VERIFICATION
218M02	2180501	ON-ORBIT PROBLEM REPORTING SYSTEM
218M03	2180301	FLUID SYS CONN INTEGRITY VERIFICATION
218M04	2180701	HABITABLE VOLUME LEAK POINT LOCATION
218M05		QA VERIFICATION
	2180201	QA On-Orbit Verification Reqmts
	2180202	QA Verification Tools and Equipment
218M07	2180203	FLUID SYSTEM VERIFICATION
218M08	2180302	EQUIPMENT STATUS MARKING ON-ORBIT
218M09	2180602	ON-ORBIT QUALITY ASSURANCE RECORDS
218M10	2180401	ON-ORBIT SYSTEM CERTIFICATION REQUIREMENTS
220M01		EQUIPMENT STANDARDS
	2200101	Equipment Vibration/Mounting Standards
	2050103	Zero-G Equipment Noise Standards
301M01		ON-ORBIT TRAINING
	3010103	On-Orbit OJT Training Cost and Benefits
	3010403	On-Orbit Refresher Training
	3010301	Non-Critical Task Training On-Orbit
303M01	3030102	WALL ACCESS/REPAIR
306M01		CREW ACTIVITY SCHEDULING
	3060102	Shift Options
	3060103	Mission Length Requirements
	3060104	Varied Crew Schedule Models
	3060106	Rec/Leisure Time Requirements
	3060108	Rest Break Requirements
	3060111	Shift Effects on Performance
	3060301	Factors for Work Scheduling
306M02	3060302	DEVELOP EXPERT SCHED SYSTEM REQUIREMENTS
306M03	3060101	IVA/EVA TASKS AND LEARNING CURVES
306M04	3060304	GRD SUPPORT FOR LONG-RANGE PLANNING
306M05	3060201	IMPORT/ESSEN SKILLS FOR JOB ROTATION
306M06	3060107	PRODUCTIVITY FACTORS
308M01	3080101	ORGANIZATIONAL STRUCTURE

LIST OF MANAGEMENT PLANS

CROSS REFERENCE LISTING

MGMT. PLANS	ISSUE	REQUIREMENTS
101M01	1010201	10102-01
101M01	1010201	10102-06
101M01	1010401	10104-05
101M01	1010701	10107-01
101M01	1010801	10108-01
102M01	1020101	10201-01
102M01	1020301	10203-01
103M01	1030101	10301-01
103M01	1030201	10302-01
103M01	1030301	10303-10
103M02	1030302	10303-04
104M01	1040001	10400-01
105M01	1050201	10501-01
105M01	1050201	10502-01
105M01	1050201	10502-02
105M01	1050201	10502-03
105M01	1050301	10503-03
105M01	1050401	10504-01
106M01	1060101	10601-01
106M01	1060101	10603-01
106M02	1060102	10601-02
106M02	1060102	10603-03
106M02	1060102	10607-01
106M02	1060102	10607-03
109M01	1090101	10901-01
109M01	1090101	10901-02
109M01	1090101	10901-03
109M01	1090101	10901-04
109M01	1090101	10901-05
109M01	1090101	10901-09
109M01	1090101	10901-20
109M01	1090601	10906-01
109M02	1090401	10904-01
109M02	1090401	10904-02
109M03	1090301	10903-01
109M03	1090301	10903-02
109M03	1090301	10903-03
201M01	2010101	20101-02b
201M01	2010101	20101-02a
201M03	2010202	20102-02d

CROSS REFERENCE LISTING

MGMT. PLANS	ISSUE	REQUIREMENTS
201M04	2010203	20102-02c
201M05	2010301	20103-01
201M05	2010302	20103-08
201M06	2010303	20103-02
201M06	2010303	20103-06
201M06	2010303	20103-12
202M01	2020101	20201-01
202M01	2020101	20202-01
202M01	2020101	20203-01
202M01	2020102	20201-02
202M02	2020103	20201-05
202M02	2020104	20201-03
202M02	2020105	20201-04
202M02	2020801	20208-01
202M02	2021001	20210-01
202M03	2020501	20205-01
202M03	2020502	20205-01
202M03	2020503	20205-02
202M03	2020504	20205-02
202M04	2020401	20204-01
202M04	2020401	20204-02
202M05	2021201	20212-01
202M05	2021201	20212-02
202M06	2020106	20201-06
203M01	2030201	20302-03
203M01	2030202	20302-01
203M01	2030401	20304-01
203M01	2030501	20305-01
204M01	2040101	20401-03
205M01	2050101	20501-04
205M02	2050102	20501-03d
205M03	2050201	20502-01h
205M03	2050201	20503-02
205M03	2050201	20503-03
207M01	2070104	20701-05
207M01	2070104	20903-06
207M01	2070104	20906-04
207M02	2070301	20703-07

MGMT. PLANS	ISSUE	REQUIREMENTS
207M03	2070401	20704-01
207M03	2070402	20704-03
209M01	2090101	20901-03
209M01	2090101	20901-06
209M01	2090101	20901-07
209M01	2090101	20906-01
209M01	2090101	20906-02
209M01	2090101	20906-07
209M01	2090101	20906-11
209M01	2090101	20906-12
209M01	2090101	20907-02
209M01	2090102	20901-05
209M01	2090102	20903-01
209M01	2090102	20903-05
209M01	2090102	20903-06
209M01	2090102	20906-04
209M01	2090102	20906-05
209M01	2090102	20906-08
209M01	2090102	20906-09
209M01	2090102	20907-01
209M01	2090201	20902-07
209M01	2090201	20902-11
209M01	2090201	20907-01
209M01	2090202	20902-08
209M01	2090202	20902-10
209M01	2090301	20903-06
209M01	2090302	20903-07
209M01	2090302	20906-06
209M01	2090302	20906-10
209M01	2090501	20905-03
211M01	2110801	21108-02
212M01	2120201	21202-03
212M01	2120202	21202-05
212M01	2120202	21202-06
212M01	2120701	21207-01
213M01	2130202	21302-02
213M01	2130202	21302-03
213M01	2130202	21302-04
213M01	2130202	21302-05
213M01	2130202	21302-07
213M01	2130202	21303-01
213M01	2130202	21303-02
213M01	2130202	21303-04
213M02	2130701	21307-02
213M03	2130101	21301-01
213M03	2130101	21301-02
213M03	2130101	21301-04

MGMT. PLANS	ISSUE	REQUIREMENTS
213M03	2130101	21301-05
213M03	2130101	21303-04
213M03	2130101	21308-01
213M05	2130501	21305-01
213M06	2130601	21306-01
213M06	2130601	21306-02
213M06	2130601	21306-04
214M02	2140102	21401-05
214M03	2140201	21402-01
214M03	2140201	21402-04
215M01	2150101	21501-02
215M01	2150101	21501-06
215M01	2150201	21502-05
215M01	2150501	21505-01
218M01	2180601	21806-02
218M02	2180501	21805-01
218M02	2180501	21805-02
218M02	2180501	21805-03
218M03	2180301	21803-05
218M04	2180701	21807-01
218M05	2180201	21802-01a
218M05	2180201	21801-02c
218M05	2180202	21802-01c
218M05	2180202	21802-01j
218M07	2180203	21802-01d
218M08	2180302	21803-01a
218M09	2180602	21806-02
218M10	2180401	21802-01c
218M10	2180401	21802-01j
218M10	2180401	21804-03
220M01	2050103	20501-01
220M01	2050103	20501-02
220M01	2050103	20505-02
220M01	2050103	22002-01
220M01	2200101	22001-01
220M01	2200101	22001-02
301M01	3010103	30101-05

CROSS REFERENCE LISTING

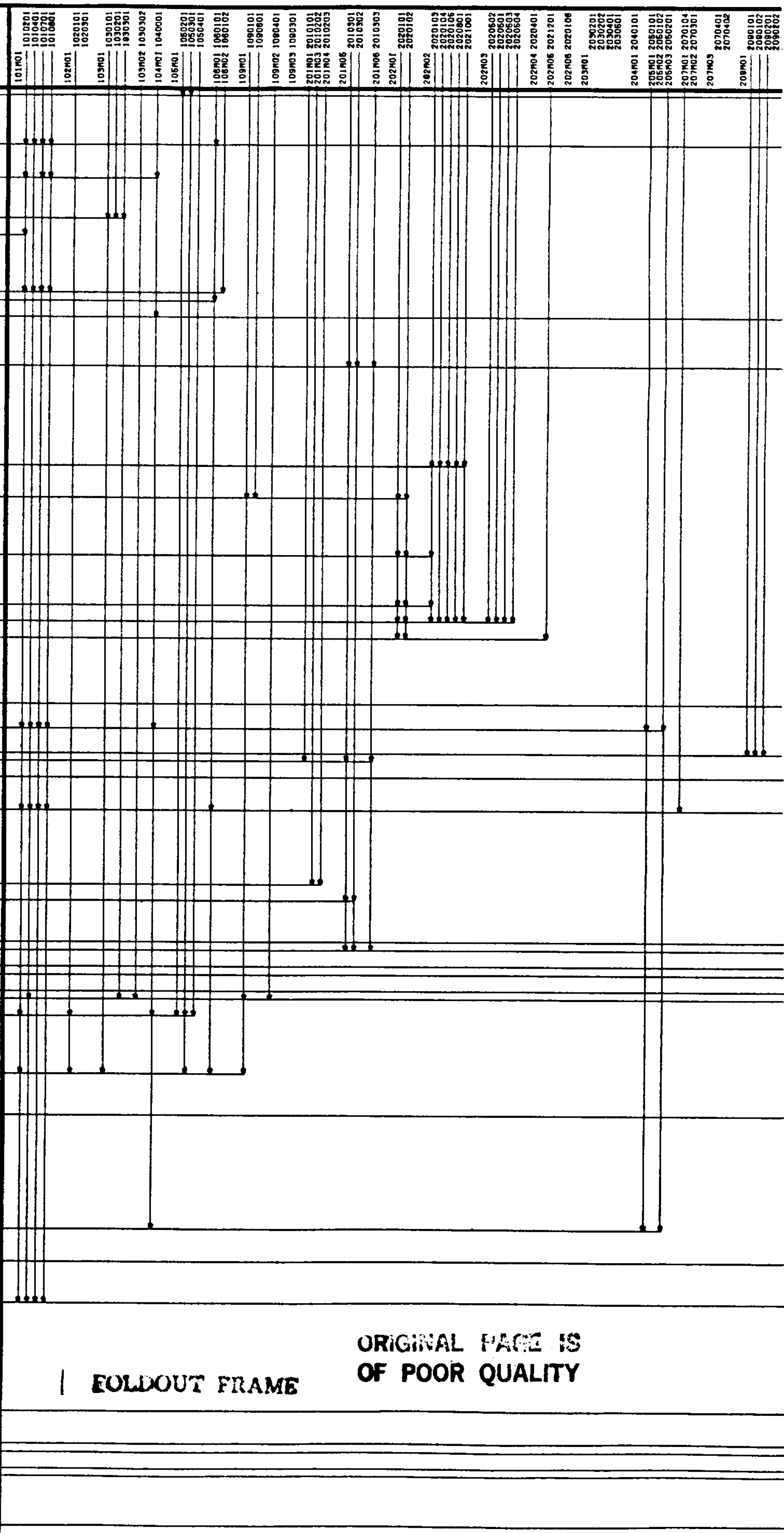
MGMT. PLANS	ISSUE	REQUIREMENTS
301M01	3010301	30103-02
301M01	3010403	30104-04
301M01	3060109	30601-32
301M01	3060109	30601-33
303M01	3030102	30301-08
306M01	3060301	30601-02
306M01	3060301	30601-07
306M01	3060301	30601-13
306M01	3060301	30603-07
306M01	3060301	30603-10
306M01	3060301	30603-12
306M01	3060301	30603-16
306M01	3060301	30603-21
306M01	3060301	30603-25
306M01	3060103	30601-19
306M01	3060102	30601-09
306M01	3060104	30601-26
306M01	3060106	30601-28
306M01	3060108	30601-30
306M01	3060111	30601-34
306M02	3060302	30603-02
306M02	3060302	30603-11
306M02	3060302	30603-15
306M02	3060302	30603-17
306M02	3060302	30603-19
306M02	3060302	30603-22
306M03	3060101	30601-01
306M03	3060105	30601-27
306M04	3060304	30603-01
306M04	3060304	30603-02
306M05	3060201	30602-07
306M05	3060201	30602-08
306M06	3060107	30601-29
306M07	3060201	30602-07
306M07	3060201	30602-08
308M01	3080101	30801-18
308M01	3080101	30801-21
308M01	3080101	30801-23
308M01	3080101	30801-24
308M02	3080204	30802-01
309M01	3090101	30901-01

CROSS REFERENCE LISTING

MGMT. PLANS	ISSUE	REQUIREMENTS
309M02	3090103	30901-06b
309M03	3090102	30603-02
309M03	3090102	30901-05a
401M01	4010201	40102-01g
401M01	4010201	40102-02a
401M01	4010201	40102-02b
401M01	4010201	40102-02c
401M01	4010201	40102-03a-e
401M01	4010201	40102-04a-e
401M02	4010202	21801-02c

MANAGEMENT PLAN RELATIONSHIPS

101M01		COMPARTMENT ARRANGEMENT & VOLUME GUIDELINES
	1010201	MINIMUM ACTIVITY AREA VOLUME REQUIREMENTS
	1010401	MULTI-USE VS DEDICATED SPACE CRITERIA
	1010701	COMPARTMENT/AREA ADJACENCY CRITERIA
	1010801	MODULE/ACTIVITY AREA ORIENTATION STANDARD
102M01		TRAFFIC FREQUENCY & WORKSTATION LOCATION
	1020101	TRAFFIC FREQUENCY DETERMINATION
	1020301	WORKSTATION LOCATIONS CRITERIA
103M01		INTERIOR DESIGN GUIDELINES
	1030101	INTERIOR DESIGN GUIDELINES
	1030201	INTERIOR DESIGN MODIFIABILITY PROVISIONS
	1030301	COLOR, LABEL, AND PATTERN CODING CRITERIA
103M02	1030302	INTERIOR LOCATION COORDINATE SYSTEM
104M01	1040001	HAB INTERIOR MATERIALS SELECTION REQUIREMENTS
105M01		ANTHROPOMETRIC DATA DEVELOPMENT
	1050201	ANTHROPOMETRIC RANGE
	1050301	NEUTRAL BODY POSTURE DATA DEVELOPMENT
	1050401	GROWTH AND ANTHROPOMETRIC CRITERIA
106M01	1060101	INTERIOR VOLUME REARRANGEMENT REQMTS
106M02	1060102	STANDARD HARDWARE AND INTERFACE REQMTS
109M01		EQUIPMENT & FOOD STOWAGE: IOC & GROWTH
	1090601	STOWAGE CONFIGURATION
	1090801	STOWAGE VOLUME & CONFIGURATION FOR GROWTH
109M02	1090401	DATA FILE STOWAGE REQUIREMENTS
109M03	1090901	TRASH-WASTE STOWAGE AND STORAGE
201M01	2010101	ATMOSPHERE SPECIFICATION
201M03	2010202	MAINTAIN/TEST POTABLE WATER PURITY
201M04	2010203	WATER ALLOCATION FOR CREW SUPPORT
201M05		CONTAMINATION: LIMITS & GASEOUS LOAD MODEL
	2010301	GASEOUS CONTAMINANT LOAD MODEL
	2010302	MICROBIAL LOAD MODEL
201M06	2010303	CONTAMINATION LIMITS
202M01		RADIATION MONITORING SYSTEM
	2020101	RADIATION MONITORING SYSTEM
	2020102	PERSONNEL DOSIMITRY
202M02		SHIELDING PROTECTION
	2020103	OPTIMAL SHIELDING DISTRIBUTION
	2020104	WINDOW RADIATION PROTECTION
	2020105	SHIELDED STORAGE
	2020801	MICROMETEORITE AND DEBRIS PROTECTION
	2021001	RADIATION SHIELDING STRATEGY FOR GROWTH
202M03		SOLAR FLARE PROTECTION
	2020502	SOLAR FLARE PROTECTION
	2020501	SOLAR FLARE RISK
	2020503	SOLAR FLARE CONTINGENCY PLANNING
	2020504	SOLAR FLARE WARNING SYSTEM
202M04	2020401	HZE PARTICLE PROTECTION FEASIBILITY
202M05	2021201	GROUND SUPPORT FOR RADIATION PROTECTION
202M06	2020106	RADIATION AWARENESS TRAINING
203M01		INDUCED ENVIRONMENT PROTECTION
	2030201	EM LEAKAGE SPECIFICATIONS
	2030202	RF/MICROWAVE EXPOSURE LEVELS
	2030401	LASER LIGHT PROTECTION OPTIONS
	2030501	SYNERGISTIC INDUCED ENVIRON EFFECTS
204M01	2040101	PHYSIOLOGICAL EFFECTS OF LIGHT
205M01	2050101	PREDICTION OF LOW FREQUENCY NOISE
205M02	2050102	LOW FREQUENCY NOISE CONTROL
205M03	2050201	LONG DURATION O-G NOISE EXPOSURE LIMITS
207M01	2070104	ZERO-G SPORTS AND GAMES
207M02	2070301	ANIMAL PAYLOAD BIOISOLATION
207M03		TASK PERFORMANCE ASSESSMENT
	2070401	ZERO-G VISUAL PERF. CRITERIA
	2070402	CRITICAL TASK PERF. ASSESSMENT
209M01		ZERO-G RECREATION
	2090101	INDIVIDUAL RECREATIONAL PREFERENCES
	2090102	O-G REC. ACTIVITIES, EQUIPMENT, AND MATLS
	2090201	FACILITY FOR GROUP RECREATION
	2090202	FACILITY FOR INDIVIDUALIZED RECREATION
	2090301	OFF-SHELF RECREATIONAL EQUIPMENT FEASIBILITY
	2090302	INNOVATIVE RECREATIONAL PROVISIONS
	2090601	RECREATION OBJECTIVES
211M01	2110801	POTABLE WATER
212M01		HOUSEKEEPING ITEMS AND EQUIPMENT
	2120201	CLEANING MATERIALS
	2120202	HOUSEKEEPING EQUIPMENT
	2120701	HOUSEKEEPING EQUIPMENT-GROWTH
213M01	2130202	WASTE AND TRASH COLLECTION METHODS
213M02	2130701	CONTINGENCY TRASH DISPOSAL METHODS
213M03	2130101	WASTE/TRASH GENERATION MODEL
213M05	2130501	WASTE/TRASH EQUIP TRANSFER
213M06	2130801	TRASH COMPACTOR REQUIREMENTS
214M02	2140102	MODULE DOCKING AIDES
214M03	2140201	INVENTORY MANAGEMENT SYSTEM DEVELOPMENT
215M01		RESTRAINTS
	2150101	STANDARDIZED FOOTWEAR/FOOT RESTRAINT SYSTEM
	2150301	CABLE AND HOSE MANAGEMENT SYSTEM
	2150302	EQUIPMENT RESTRAINTS
	2150201	BODY RESTRAINTS
	2150501	CREW PORTABLE RESTRAINT SYSTEM
216M01		EQUIPMENT RESTRAINT & TRANSFER
	2160201	CONTAINMENT & TRANSLATION OF EQUIPMENT
	2160101	CREW TRANSLATION AIDS
	2160102	INADVERTENT IMPACT PROTECTION
218M01	2180601	ON-ORBIT CONFIGURATION MODS VERIFICATION
218M02	2180501	ON-ORBIT PROBLEM REPORTING SYSTEM
218M03	2180301	FLUID SYS COMM INTEGRITY VERIFICATION
218M04	2180701	HABITABLE VOLUME LEAK POINT LOCATION
218M05		QA VERIFICATION
	2180201	QA ON-ORBIT VERIFICATION REQMTS
	2180202	QA VERIFICATION TOOLS AND EQUIPMENT
218M07	2180203	FLUID SYSTEM VERIFICATION
218M08	2180302	EQUIPMENT STATUS MARKING ON-ORBIT
218M09	2180802	ON-ORBIT QUALITY ASSURANCE RECORDS
218M10	2180401	ON-ORBIT SYSTEM CERTIFICATION REQUIREMENTS
220M01		EQUIPMENT STANDARDS
	2200101	EQUIPMENT VIBRATION/MOUNTING STANDARDS
	2050103	ZERO-G EQUIPMENT NOISE STANDARDS
301M01		ON-ORBIT TRAINING
	3010103	ON-ORBIT OJT TRAINING COST AND BENEFITS
	3010403	ON-ORBIT REFRESHER TRAINING
	3010501	NON-CRITICAL TASK TRAINING ON-ORBIT
303M01	3030102	WALL ACCESS/REPAIR
306M01		CREW ACTIVITY SCHEDULING
	3060102	SHIFT OPTIONS
	3060103	MISSION LENGTH REQUIREMENTS
	3060104	VARIED CREW SCHEDULE MODELS
	3060106	REC/LEISURE TIME REQUIREMENTS
	3060108	REST BREAK REQUIREMENTS
	3060111	SHIFT EFFECTS ON PERFORMANCE
	3060301	FACTORS FOR WORK SCHEDULING
306M02	3060302	DEVELOP EXPERT SCHED SYSTEM REQUIREMENTS
306M03	3060101	IVA/EVA TASKS AND LEARNING CURVES
306M04	3060304	GRD SUPPORT FOR LONG-RANGE PLANNING
306M05	3060201	IMPORT/ESSEN SKILLS FOR JOB ROTATION
306M06	3060107	PRODUCTIVITY FACTORS
308M01	3080101	ORGANIZATIONAL STRUCTURE
308M02	3080204	AIR-TO-GROUND PROBLEM RESOLUTION
309M01	3090101	AUTONOMY TECH SELECTION/TIME PHASING
309M02	3090103	ON-ORBIT VS GRD OFF-NOMINAL ACT. PROTOCOLS
309M03	3090102	ON-ORBIT VS GRD TASK ASSIGNMENT
310M01	3100101	ANTHROPOMETRIC COMPUTER MODELING
310M02	3100201	WORKLOAD ASSESSMENT COMPUTER MODEL
401M01	4010201	WORKSTATION DESIGN GUIDELINES
401M02	4010202	TASK VERIFICATION AT WORKSTATIONS



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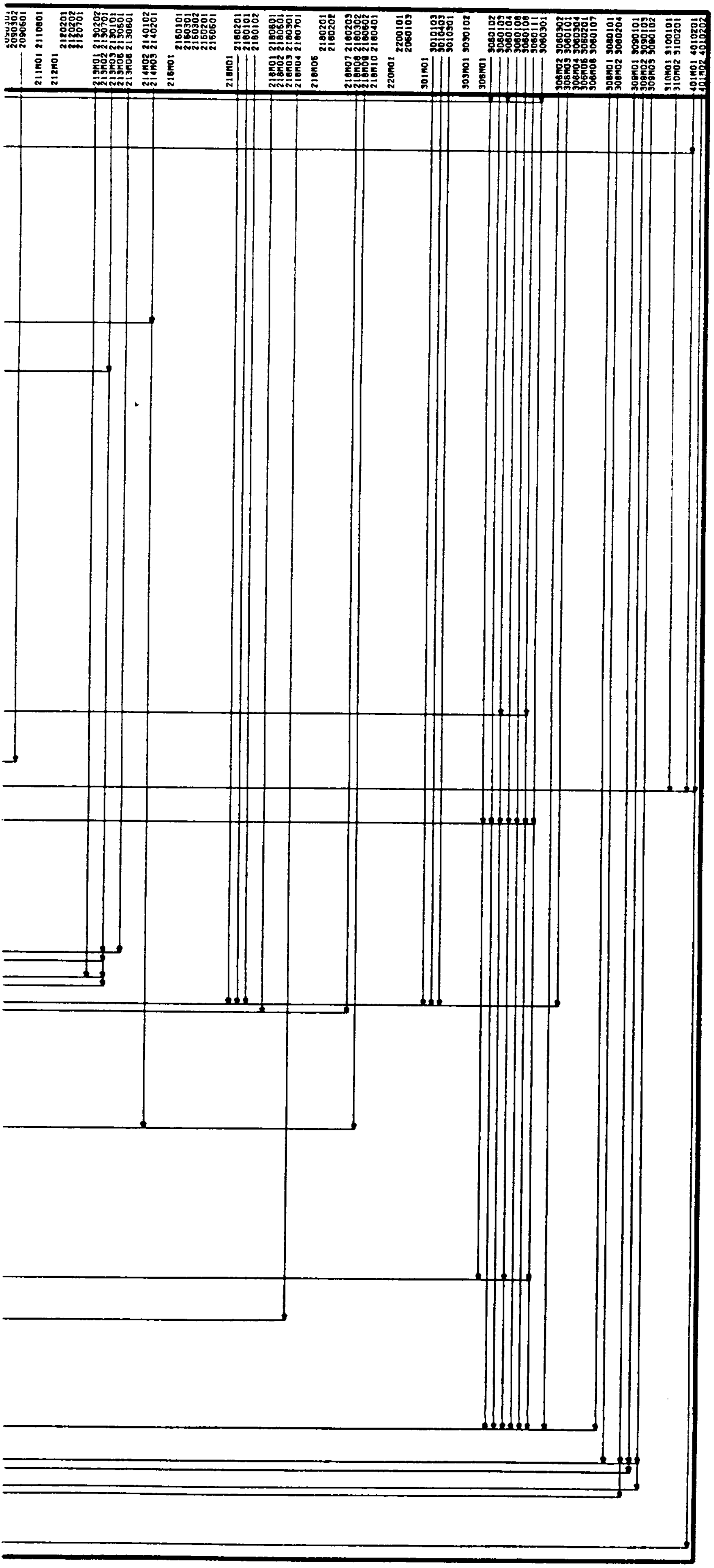

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Management Plan Relationships Matrix

GLOSSARY

ACGIH	American Conference of Government & Industry Hygienists
AF	Air Force
AI	Articulation Index
ANSI	American National Standard Institute
ASE	airborne support equipment
ATAC	Advanced Technical Advisory Committee
BP	blood pressure
C	centigrade
C&T	communications & tracking
CAD	computer aided design
CCTV	closed circuit television
CDG	Configuration Design Guidelines
CO2	carbon dioxide
CRT	cathode ray tube (TV screen)
CSD	contract start date
CVD	cardiovascular deconditioning
db	decibels
dBA	decibel, A scale
dBC	decibel, C scale
DBMS	database management system
E-Field	electric field
ECG	electrocardiogram
ECLS	environment control life support
ECLSS	environmental control & life-support system
EEU	extravehicular excursion units
El	electro-luminescent
EM	electromagnetic
EMI	electromagnetic interference
EMU	extravehicular mobility unit
EVA	extravehicular activity
F	farenheit
Ft-C	foot candles
Ft-L	foot lamberts
+GZ	positive acceleration gravity vector, head to foot (least tolerance)
H-Field	magnetic field
H2O	water
HEPA	high efficiency particulate air
HMF	health maintenance facility
HMS	habitability manned system
HOL	higher-order language
HPD	hearing protection device
hr	hour
HR	heart rate
HZ	hertz
HZE	high energy Z particles
IDMS	Space Station information & data management system
IMS	inventory management system
IMSS	in-flight medical support system
IOC	initial operating capability
IR	infra-red
ISO/TC	International Standards Organization/technical circular
IV	intravenous
IVA	intravehicular activity
JSC	Johnson Space Center
k	kilo
K	Kelvin

LA	noise level in dBA
LCD	liquid crystal display
LED	light emitting diode
LET	linear energy transfer or ionization rate along particle track
LSRM	Life Sciences Research Module
Leq	equivalent noise level (average over a specified duration)
MDBMS	medical database management system
MIL-STD	military standard
MMU	manned manuvering unit
MPAC	multipurpose applications console
MSFC	Marshall Space Flight Center
MSIS	Manned Systems Integration Standards
MSS	manned space station
N2	nitrogen
NASA	National Aeronautics & Space Administration
NC	noise criterion curve
NHB	NASA handbook
NOS	Network Operating System
NSTS	national space transportation system (shuttle)
OBL	octave band level
ODD/LDD	observed daily duration noise/limited daily duration noise
ODDNet	optical data distribution network
ORU	orbital replacement unit
PI	principal investigator
RF	radio frequency
RFP	Request for Proposal (9-BF-10-4-01P, Space Station Definition and Preliminary Design, 15 Sept 84)
SDP	subsystem data processor
SIL	speech interference level
SMS	space motion sickness
SOMS-A	shuttle on-board medical system, A modification
SSP	Space Station Program
SSPE's	Space Station program elements
STS	Space Transportation System
Specs	specifications
TBD	to be determined
TV	television
UV	ultra-violet
WMS	waste management system

REPORT FORMAT 13 MANAGEMENT PLAN OVERVIEW

NUMBER	TITLE	DATE
101M01	COMPARTMENT ARRANGEMENT & VOLUME GUIDELINES	06-26-85

ISSUE #	TITLE	NEED DATE
1010801	MODULE/ACTIVITY ORIENTATION STANDARD	Oct 86
1010401	MULTI-USE VS DEDICATED SPACE CRITERIA	
1010701	COMPARTMENT ADJACENCY CRITERIA	
1010201	MINIMUM ACTIVITY AREA VOLUME REQUIREMENTS	

OBJECTIVES:

(01) To develop a basis for establishing visual reference guidelines.

(02) To establish principles for allocating space to multipurpose of dedicated uses.

(03) To develop criteria for placing compartments adjacent to each other.

(04) To determine the minimum volume per crew member that will facilitate work and personal needs.

BACKGROUND:

The dual goals of efficiency and personal comfort must be met on space station if human productivity is to be enhanced. While each of the four objectives of this plan is addressed independently, they are united under a common concern, the best use of a limited space in zero-gravity.

Humans, with few exceptions, have had no experience with anything other than a "top, bottom", "earth, sky" visual reference. However, living and working in a zero-g environment has some obvious advantages if humans are sufficiently adaptable with regard to orientation. The problems of visual orientation of concern here are two-fold; module to module orientation and equipment placement. A direct test of equipment placement would be limited, at best, and past experience is probably the primary, if not the best guide. However, if movement from module to module requires a constant visual orientation, especially if that orientation must be relative to earth, it will constrain module design and drive module costs. The difficulty of simulating zero-g prevents a direct test of any of the alternatives, but other means can be used to generate some data of a type that will permit guidelines for visual orientation to be formulated.

The multiple use of a compartment and the relationship of one compartment to another, what is adjacent to what, are both factors which depend on the activity to be performed in that space. As a practical matter, spaces which can have more than one use will lead to efficiency and to expanded capabilities. In order to avoid conflicts which reduce productivity, guidelines for determining complementary and exclusive activities and for physical relationships between areas (next to and far from) need to be available. While guidelines for

combining activities which can share a common area do exist, they need to be reviewed and, where necessary, related to the zero-g environment and to the limited volume of space station. Where problems peculiar to space station are not addressed, new guidelines need to be created. Criteria for compartment location also need to be established on the basis of activity.

One additional set of requirements, volume per crew member by activity, are necessary if the crew is to be productive. In a constrained space, the minimum volume that a crew member requires must be defined. The volume requirements represent a trade-off. Volume per activity puts limits on the number of activities or functions which can take place in a defined space. On the other hand, activity which is determined without allowing for adequate crew-member volume, will require more time to be performed, may be performed at a higher error rate, or both.

While each of these four objectives is unique, each has an impact on the other. It is the purpose of this plan to take these characteristics into consideration and to provide a package of information which will address the entity. It is suggested that this work be combined, or at least done simultaneously, with the management plan which addresses workstation location criteria and traffic frequency (management plan 102M01).

INPUTS:

A. Crew activity scheduling to include the available information from factors for work scheduling, issue 3060301; shift options, issue 3060102; and crew schedule models, issue 3060104.

B. Anthropometric data for zero-g: neutral body posture data, issue 1050301; and anthropometric range, issue 1050201; and 4th Capacity Device, NASA Contract NAS9-15800(1).

CRITICAL ASSUMPTIONS:

(01) The appropriate anthropometric data will be available to determine volume requirements.

(02) SDR will be no earlier than December 86.

SPECIAL REMARKS:

(01) The visual orientation principles could be validated through research done on Spacelab.

(02) While the effects of zero-g on auditory orientation are not within the scope of this management plan, sound localization may well be an orienting, or disorienting, factor in the space station environment.

REFERENCES:

(01) R.A. Lewis, Personal Communication, POC LEMSCO (713)333-6148, Jun 1985

REPORT FORMAT 14 STUDY PLAN

NUMBER	TITLE	DATE
101M01	COMPARTMENT ARRANGEMENT & VOLUME GUIDELINES	06-26-85

STUDY TASKS:

(01) Develop visual reference guidelines:

a. Review space related literature and interview astronauts for visual orientation preferences.

b. Review visual perception literature for related or analogous data.

c. Perform demonstrations or field research to define visual preference in one-g using NASA mock-ups or simulators. Figures 1 and 2 show possible configurations. The design should include acquisition of structured, subjective data and the use of dependent measures where feasible.

d. Based on the information gathered and data generated, develop criteria and guidelines.

(02) Identify activities which can be colocated and those which require dedicated space.

a. Review space literature in order to identify past activities in long duration missions. Where possible, create categories which will encompass these activities.

b. Identify relevant on-going research, e.g., factors for work scheduling, crew schedule models, to identify additional activities, number of crew involved, and time of occurrence.

c. Interview or have a conference with NASA, JSC, Manned Systems Division personnel to confirm the data which has been acquired and the categories which have been developed. Based on this and any additional information, general principles for aggregating and separating activities will be structured.

(03) Determine criteria for physical relationships among compartments, adjacency.

a. Using the background material from task three, construct a list of compartments, or activities, which must be removed or isolated from other compartments.

b. Interview experienced astronauts, especially Skylab astronauts, to elicit adjacency preferences. A structured interview using an activities list should allow some general preferences and principles to emerge.

c. Based on the information acquired in 'b.', develop a series of drawings illustrating a range of preferences and possibilities.

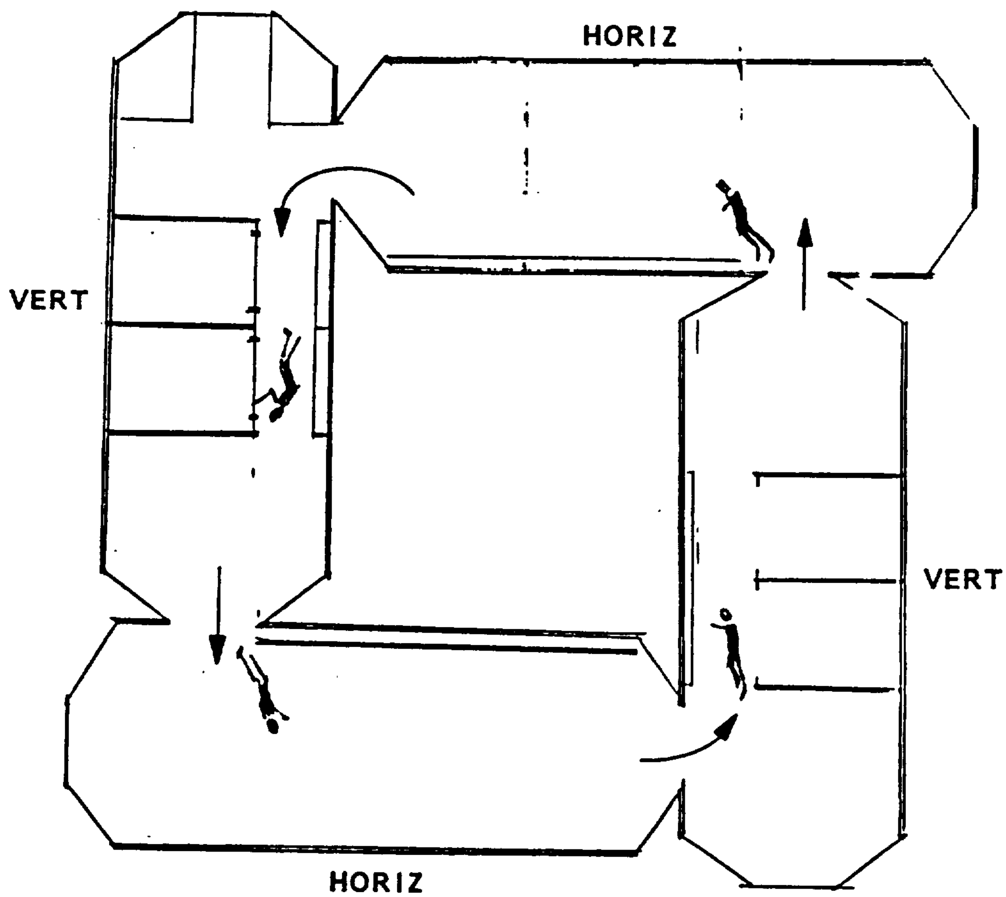
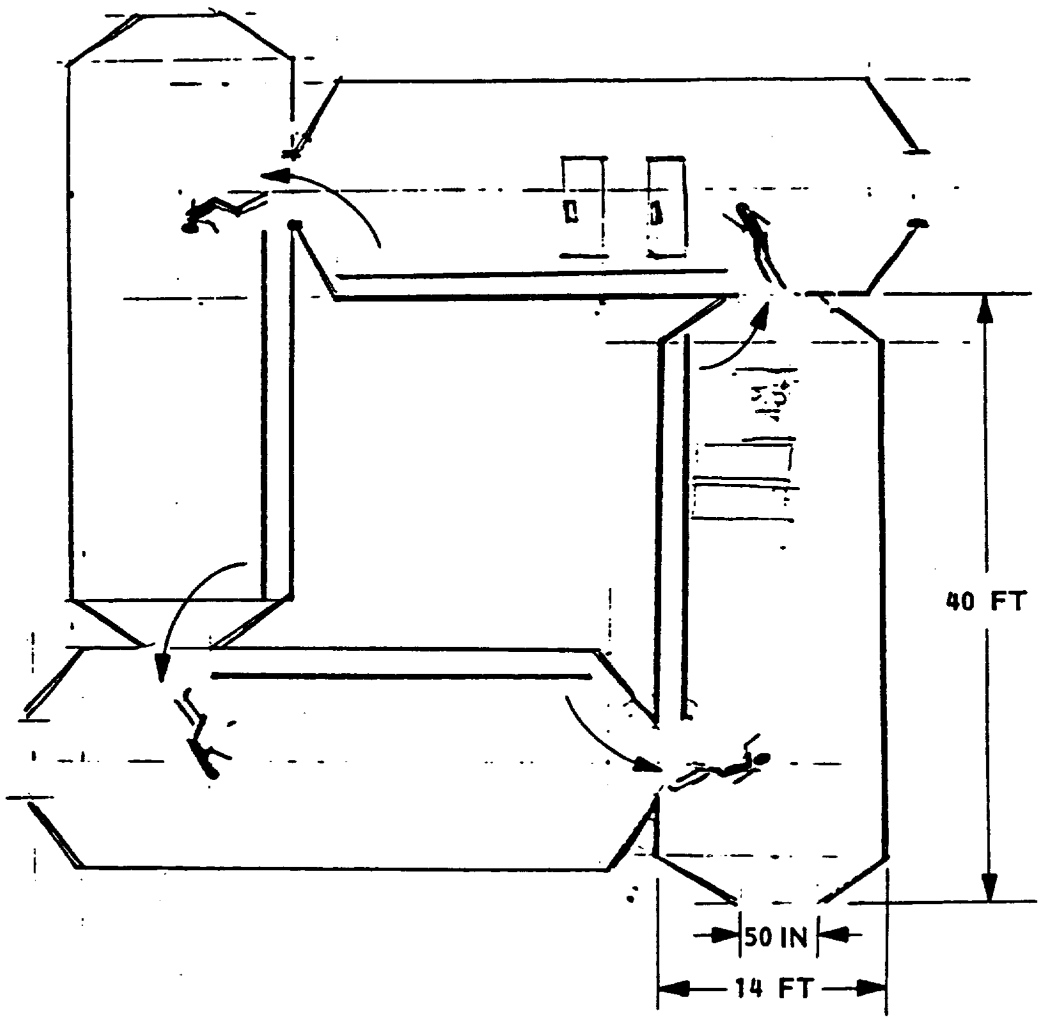


FIGURE 1 (MANAGEMENT PLAN 101M01)
SPACE STATION WITH MIXED
VERTICAL AND HORIZONTAL WITHIN
MODULE ORIENTATIONS



HORIZONTAL DECK
ARRANGEMENT

FIGURE 2 (MANAGEMENT PLAN 101M01)
SPACE STATION WITH CONSISTENT
HORIZONTAL WITHIN MODULE
ORIENTATION

d. Interview a new set of astronauts, experienced if possible, and have all illustrations rank ordered by paired comparisons. Reasons for preferences should be recorded.

(04) Develop guidelines for colocation of activities and compartment adjacencies.

(05) Develop minimum volume for crew member activities.

a. Review and analyze anthropometric data and models. Consult social psychologist about "personal space" needs. Develop preliminary volume requirements by isolated activities to include contingency EMU using a computer aided design (CAD) system.

b. If a sophisticated CAD system is available, the interaction of volume and activity by multiple crew may be possible. It may be necessary to build full scale models in order to do an actual assessment of the preliminary volume guidelines.

c. Develop volume guidelines to include limits on crew member per area for the appropriate activities. These guidelines will be developed to take visual reference guidelines and the colocation and adjacency guidelines into account.

(06) Produce final report with recommendations relating each of the four areas of concern to the entity, Space Station.

SPECIAL STUDY NEEDS:

TASK(S)	NEED
1	Access to NASA mock-ups and/or simulators.
1, 2 & 3	Access to experienced astronauts.
5	CAD system

SPECIAL SKILLS:

TASK(S)	SKILL
1	Human Factors personnel with background in visual perceptions.
4	Social anthropologist or psychologist

PERFORMING ORGANIZATION:

(01) Managing: NASA, JSC

(02) Doing: Aerospace Firms (Prime)
Consultants (Subs)

STUDY PRODUCTS:

(01) Visual Reference Guidelines

(02) Space Allocation and Adjacency Guidelines

(03) Volume Requirements for Crew Members

PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS:

SUBELEMENT NO. & TITLE		Undefined Rqmt #
10108	INTER/INTRA-MODULE EQUIPMENT ORIENTATION	-01
10104	SPACE UTILIZATION	-05
10701	ADJACENCIES	-01
10102	ACTIVITY VOLUME	-01, -06

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
101M01	COMPARTMENT ARRANGEMENT & VOLUME GUIDELINES	06-26-85

```
                                         1985         |    1986                              |
                                 CALENDAR|O--N--D--|J--F--M--A--M--J--J--A--S--|
                                   FISCAL|FY 86                                             |
                                    MONTH|1  2  3   4  5  6  7  8  9  10 11 12 |
                                  PHASE B|                                                  |
                                        C|                                                  |
STUDY  TASKS                             |                                                  |
ASSUMES SDR DEC 1986                     |                                                  |
1. Visual reference guideline            |-------------------------                         |
                                         |          18 mm                                   |
                                         |                                                  |
2. Identify activities & assign          |    A -------------------                         |
   locations.                            |             6 mm                                 |
                                         |                                                  |
3. Identify compartment adjacencies.     |           A ------------------                   |
                                         |                     8 mm                         |
                                         |                                                  |
4. Produce colocation & adjacency        |                                     ------       |
   guidelines.                           |                                      3 mm        |
                                         |                                                  |
5. Volume requirements.                  |                    B ---------------|
                                         |                                   5 mm           |
```

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
101M01	COMPARTMENT ARRANGEMENT & VOLUME GUIDELINES	06-26-85

	1986			1987								
CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S
FISCAL	FY 87											
MONTH	1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												
STUDY TASKS												
5. (cont)	--- 1mm											
6. Final Report		--- 1mm										

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
101M01	COMPARTMENT ARRANGEMENT & VOLUME GUIDELINES	06-26-85

SUMMARY SCHEDULE/COST FACTORS

STUDY SPAN: Oct 85-Dec 86 CM = 14

CATEGORY	FACTOR/MM(CM)*	COST $
LABOR		
- NASA Project Mgmt		
- Study Mgmt	6 MM	
- Study Tasks		
- Analyst, Eng'g	1 MM	
- Special Skills:		
	38 MM	
	4 MM	
SPECIAL FACILITIES		
Mock-ups, simulators	1 wk	
TRAVEL		
Coordination with NASA, astronauts, etc.		10 K
MATERIALS		
Models, if needed		5 K
TEST PROGRAM		
OTHER (List)		

MMs = 42

* MM = Manmonths; CM = Calendar Months

REPORT FORMAT 13 MANAGEMENT PLAN OVERVIEW

NUMBER	TITLE	DATE
102M01	TRAFFIC FREQUENCY & WORKSTATION LOCATION	06-26-85

ISSUE #	TITLE	NEED DATE
1020101	TRAFFIC FREQUENCY DETERMINATION	Sept 86
1020301	WORKSTATION LOCATION CRITERIA	

OBJECTIVES:

(01) Develop guidelines and requirements for the design of Space Station passageways.

(02) Develop workstation location criteria.

BACKGROUND:

The Space Station module volumes are a limited resource. As such, the use of the volumes must be optimized. At the same time interference with workstation activities must be avoided if not minimized. In addition, adequate clearances must be provided throughout the modules to ensure safe and reasonably comfortable passage for personnel and equipment. Damage to equipment and/or interference with workstation activities may have significant consequences to mission accomplishments and to safety.

The unique aspects of a zero-g environment require that criteria be developed which are based on operational considerations but which are directly meaningful to designers. The frequency of use of a passageway route will directly affect the associated clearance criteria, e.g., the passage clearance requirement may be larger if it is heavily traveled and passes by a critical use workstation. Passageway clearance criteria may also be affected by its location in reference to the module, e.g., central or near the periphery; near the airlock, etc. In some cases, the passageway might also serve as a part of an activity area, such as in the airlock or the clearance between the galley and dining area.

Alternatively, a critical function workstation should be located away from heavy traffic passageways, high noise, or other distracting factors. Various other considerations include anthropometric guidelines, type of workstation, EMU activity clearance for leak repair or similar depressurization contingencies, and safety concerns, such as isolation of contaminants.

An important aspect of this study is a determination of the kinds of criteria that should be addressed. This is then followed by tasks to develop appropriate guidelines which are meaningful to designers, while allowing the needed freedom to develop and evaluate alternative interior layout arrangements.

INPUTS:

A. IVA workstation descriptions and functional requirements
B. WORKSTATION DESIGN GUIDELINES (Issue 4010201)
(Early coordination & midstudy inputs recommended)
C. INTERIOR VOLUME REARRANGEMENT REQUIREMENTS (Issue 1060101)
D. COMPARTMENT ARRANGEMENT & VOLUME GUIDELINES (Mgmt. Plan 101M01)
E. Space Station on-orbit replaceable unit (module) sizes
F. Defined hatch sizes (Issue 1020401)
G. Anthropometric data: NEUTRAL BODY POSTURE IN ZERO-G (Issue 1050301); ANTHROPOMETRIC RANGE (Issue 1050201), and 4th Capacity Device, NASA Contract NAS9-15800 (1).

CRITICAL ASSUMPTIONS:

(01) Interior design shall provide for quick evacuation of all isolable modules for safety escape.

(02) Minimum hatch diameter is 50 inches (1.27m).

SPECIAL REMARKS:

(01)

REFERENCES:

(01) R.A. Lewis, Personal Communication, POC LEMSCO (713)333-6148, Jun 1985

REPORT FORMAT 14 STUDY PLAN

NUMBER	TITLE	DATE
102M01	TRAFFIC FREQUENCY & WORKSTATION LOCATION	06-24-85

STUDY TASKS:

(01) Perform a data/literature review to integrate existing requirements and guidelines relative to workstation location and passageway clearances. Consult NASA Manned System Centers to confirm comprehensive review. Develop preliminary outline of guidance and problem areas.

(02) In coordination with the WORKSTATION DESIGN GUIDELINES study effort (Issue 4010201), categorize workstation types and document early requirements for workstations which relate to volume and/or location criteria.

(03) Select candidate intra-module configurations with representative workstation types and passage clearance concerns. Perform walk-throughs of selected mission scenarios to develop potential problem areas and to define the characteristics of needed criteria. Integrate anthropometric criteria (Issues 1050201, 1050301). Selected scenarios should include nominal and worst case activities (normal and 'congested' traffic flows, EMU activities, etc.) Use of NASA simulator is recommended.

(04) Update preliminary outline of guidance requirements and problem areas. Perform analyses to develop requirements for resolving problem areas, e.g., specification of shared and non-shared volume for given work areas, workstations requiring isolation priority, etc.

(05) Complete draft of passageway and workstation location requirements and subject to review by multi-disciplinary panel. Relate to evolving WORKSTATION DESIGN GUIDELINES in order to incorporate needed criteria.

(06) Respond to review, update and issue requirements.

SPECIAL STUDY NEEDS:

TASK(S)	NEED
1	Access to NASA, Manned Systems Division expertise
3	Access to NASA simulators or mock-ups
3	Space Station design configurations

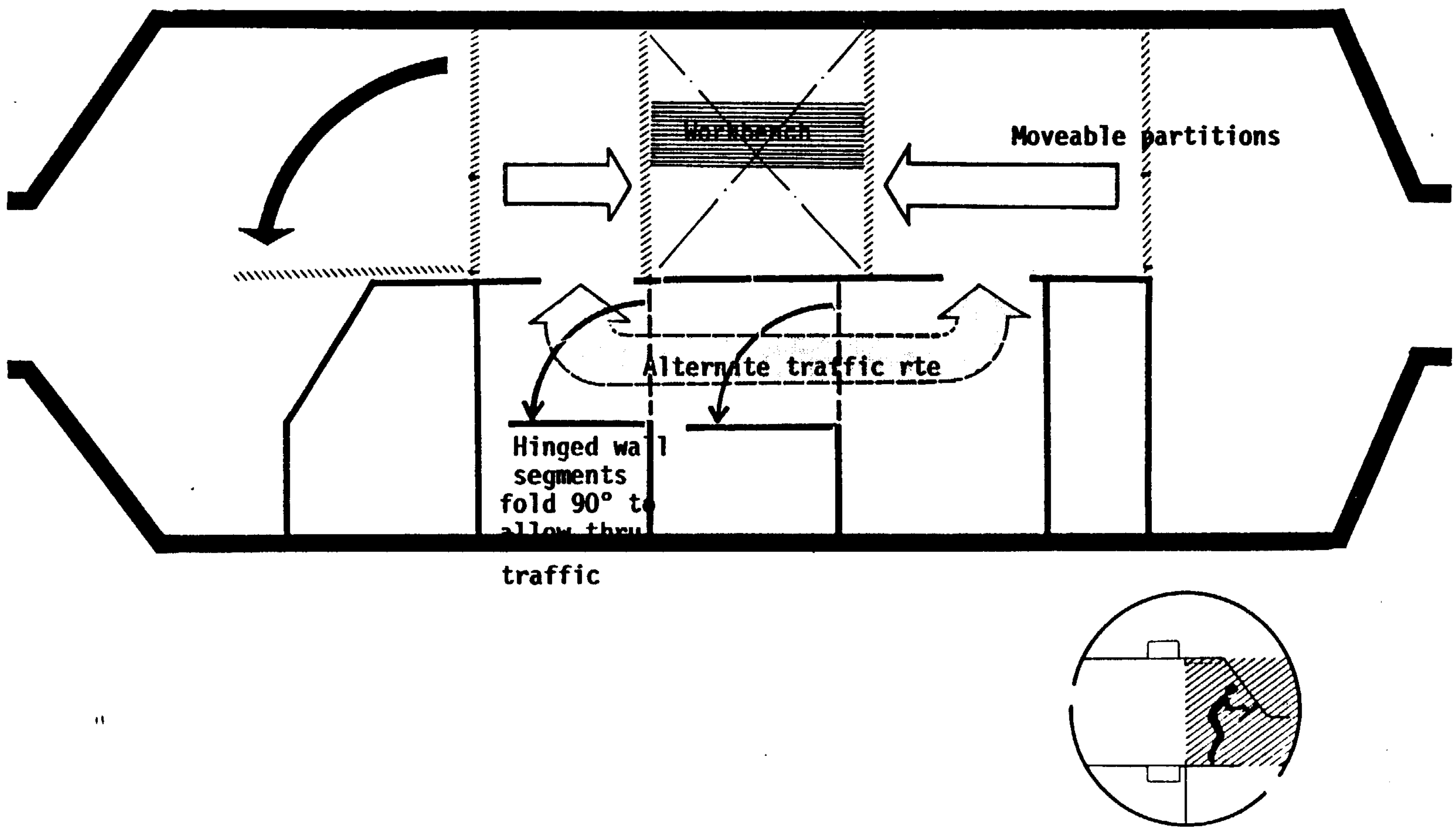


Figure 1. An example of alternate traffic routes resulting from the need for an isolated workstation location.

SPECIAL SKILLS:

TASK(S)	SKILL
1,2,3,4,5,6	Manned System Analysts, Human Factors Specialists

PERFORMING ORGANIZATION:

(01) Managing: NASA Level B

Doing: Aerospace Firms (Prime)
Consultants (Sub)

STUDY PRODUCTS:

(01) Passageway and Workstation Location Requirements

PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS:

SUBELEMENT NO. & TITLE	Undefined Rqmt #
10201 FREQUENCY OF TRANSIT	-01
10203 WORKSTATION LOCATIONS CRITERIA	-01

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
102M01	TRAFFIC FREQUENCY & WORKSTATION LOCATION	06-22-85

	1985			1986								
CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S
FISCAL	FY 86											
MONTH	1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												
STUDY TASKS												
Assumes Dec 86, SDR												
1. Review literature, develop outline	---	---	---	---	---							
			1.5 mm									
2. Develop preliminary requirements			---	---	---	---						
				1.5 mm								
3. Develop scenarios, perform walk-throughs.	A thru G				---	---	---	---	---			
							8 mm					
4. & 5. Perform data analysis & complete draft document.										---	---	---
											3 mm	

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
102M01	TRAFFIC FREQUENCY & WORKSTATION LOCATION	06-22-85

	1986			1987								
CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S
FISCAL	FY 87											
MONTH	1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												
STUDY TASKS												
6. Respond to review, update & issue requirements.	--- 1mm											

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
102M01	TRAFFIC FREQUENCY & WORKSTATION LOCATION	06-22-85

SUMMARY SCHEDULE/COST FACTORS

STUDY SPAN: OCT 85-OCT 86 CM = 12

CATEGORY	FACTOR/MM(CM)*	COST $
LABOR		
- NASA Project Mgmt	5 MM	
- Study Mgmt		
- Study Tasks		
- Analyst, Eng'g		
- Special Skills:	15 MM	

SPECIAL FACILITIES
NASA mock-ups or simulators

TRAVEL
Coordination, perform evaluation 12 K

MATERIALS

TEST PROGRAM

OTHER (List)

MMs = 15

* MM = Manmonths; CM = Calendar Months

REPORT FORMAT 13 MANAGEMENT PLAN OVERVIEW

NUMBER	TITLE	DATE
103M01	INTERIOR DESIGN GUIDELINES	06-26-85

ISSUE #	TITLE	NEED DATE
1030101	INTERIOR DESIGN GUIDELINES	May 88
1030201	INTERIOR DESIGN MODIFICABILITY PROVISIONS	May 88
1030301	COLOR,LABEL & PATTERN CODING CRITERIA	May 88

OBJECTIVES:

(01) Develop interior design guidelines for color, texture, graphics and lighting to provide a comfortable, stimulating, non-monotonous work and off-duty environment.

(02) Devise and evaluate interior design features that will allow variations in color, lighting or textures to maintain a varied and stimulating living and work environment.

(03) Develop integrated coding criteria using color, graphics, textures, and labeling approaches for identification/orientation purposes that avoid visual clutter or information overload.

BACKGROUND:

There is evidence to indicate that interior design features such as color affect human performance. For example, Soviet Space Station experience indicates that monotonous surroundings lead to boredom, fatigue, and possibly loss of job interest. Based on Soviet experience, there may also be a relationship between color and motion sickness. (1) The human factors literature (2) reveals that color and lighting produces the following responses:

o Certain colors make a space appear larger than it actually is while others cause a space to "close in" on the observer.

o Certain colors cause a space to seem "warm" while others make it seem "cool".

o Some colors appear to have a definite effect on the mood of the observer, i.e., some colors may be stimulating while other are quieting.

o Some colors seem to clash with each other and therefore produce a feeling of irritation to observers who are especially sensitive to color incompatibilities.

While it is generally acknowledged that interior design features can have a significant effect on human performance, our knowledge base does not allow clearcut specification of interior design guidelines without a detailed study of specific space station needs.

The present issue resolution management plan provides a technical approach for developing interior design guidelines and specifications. It also addresses design features for modifying the interior decor for stimulus variation purposes. Finally, the technical approach considers the development of coding criteria that are harmonious with the decor scheme to facilitate identification of spaces and maintaining orientation in the zero-g environment.

INPUTS:

A. Work and living space configurations
B. MULTI-USE VS DEDICATED SPACE DETERMINATIONS (Issue 1010701)
C. HABITABILITY INTERIOR MATERIALS SELECTION REQUIREMENT (Issue 1040001)
D. ACTIVITY AREA VOLUMES (Issue 1010201)
E. Crew characteristics
F. Crew activities in specific locations
G. Crew information needs
H. MODULE/ACTIVITY AREA ORIENTATION STANDARD (Issue 1010801)
I. SS MOTION SICKNESS COUNTERMEASURES (Issue 2070107)

CRITICAL ASSUMPTIONS:

(01) The interior decor scheme should be tailored primarily to the needs of the U.S. crew population. Secondary attention should be given to accommodating foreign participants.

(02) A full scale, one-g, space station mission simulation will be developed to simulate 90 day missions.

SPECIAL REMARKS:

(01) Judgement regarding aesthetic preferences in relation to color, graphics, texture and lighting are highly subjective. Consequently interior design guidelines require close coordination with the candidate crew population to meet their specific needs.

(02) Concern with labeling, in the context of this study plan, is confined to the color of label characters and the color of label backgrounds in relation to the overall Space Station color-decor scheme.

(03) Consideration of lighting in the present study plan is confined to the interactive effects of light and color from an aesthetic standpoint rather than general lighting requirements for effective task accomplishment.

(04) The interrelationship between color and motion sickness will be addressed separately in the management Issue #2070107 SPACE STATION MOTION SICKNESS COUNTERMEASURES.

REFERENCES:

(01) Boeing Aerospace Co., Soviet Space Stations as Analogs, D180-28182-1, Oct 1983

(02) W. Woodson, Human Factors Design Handbook, 1981

REPORT FORMAT 14 STUDY PLAN

NUMBER	TITLE	DATE
103M01	INTERIOR DESIGN GUIDELINES	06-26-85

STUDY TASKS:

(01) Literature review to establish known effects of color, texture, graphics and lighting on human performance. Consult with subject matter experts within NASA and academia.

(02) Develop design concepts for varying the interior design characterisitics, allowing for personalization of living spaces and accommodating the culturally-shaped preferences of foreign visitors.

(03) Data-gathering from space station design efforts to establish crew activities in specific space station locations and the information-orientation needs of the crew.

(04) Develop scale models that can be used to develop, present, and evaluate candidate color-decor schemes. Also establish coding practices for identification and orientation purposes that are compatible with the candidate color-decor schemes.

(05) Conduct a structured survey of a representative sample of the crew population and subject-matter experts in evaluating the candidate decor schemes and in selecting a preferred approach. Include foreign test subjects in this evaluation.

(06) Develop full scale mockups or utilize existing mockups of space station living and work areas and implement the preferred decor scheme selected on the basis of the scale model evaluation.

(07) Use full-scale mockups to verify the suitability of color-decor schemes, modifiability of features and identification-orientation coding features utilizing representative members of the crew population.

(08) Assuming the separate development of a full scale, one-g space station mission simulator for ninety-day confinement studies, implement the selected color-decor identification scheme and obtain subjective evaluation data from test subjects. Perform as add-on to primary study.

(09) Formulate interior design specifications for the space station.

SPECIAL STUDY NEEDS:

TASK(S)	NEED
4	Model-making capability
6,7	Access to full scale mockups
8	Access to mission simulation
3,2	Availability of space station configuration data, crew task analyses data, and material selection guidelines.
5,7	Access to the candidate crew population and

NASA experts.

SPECIAL SKILLS:

TASK(S)	SKILL
2,4,6	Industrial Design
1,2,5,7,8	Human Factors; Environmental Psychologist
1,2,7	Crew Syst Design, Interior Design Specialists

PERFORMING ORGANIZATION:

(01) Managing: NASA Laboratories

(02) Doing: Aerospace Firms (Prime)
Industrial Design Firms (Sub)

STUDY PRODUCTS:

Detailed design specifications for:

(01) Space Station interior design features for the various living and work spaces: color, graphics, texture, and lighting in terms of their impact on decor.

(02) Design features to allow modificability of decor to provide stimulus variation and personalization of spaces.

(03) Recommended coding-labeling approaches that are harmonious with the overall decor scheme and that provide effective indication and orientation cues for crew members.

PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS:

SUBELEMENT NO. & TITLE		Undefined Rqmt #
10301	Decor,Texture,Graphics & Lighting	-01
10302	Interior Design Modifiability	-01
10303	Coding	-10

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
103M01	INTERIOR DESIGN GUIDELINES	06-26-85

	1985			1986								
CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S
FISCAL	FY 86											
MONTH	1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												
STUDY TASKS												
1. Literature Review	------	------ (2m/m)										
2. Modifiability Design Concepts			------	------	------ (4m/m)	------						
3. SS Design Data-Gathering							------	------	------	------	------ (4m/m)	

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
103M01	INTERIOR DESIGN GUIDELINES	06-26-85

```
                              1986       ¦    1987                        ¦
                      CALENDAR¦O--N--D--¦J--F--M--A--M--J--J--A--S¦
                        FISCAL¦FY 87                                       ¦
                         MONTH¦1  2  3   4  5  6  7  8  9 10 11 12¦
                       PHASE B¦                                            ¦
                             C¦                                            ¦
STUDY  TASKS                  ¦                                            ¦
                              ¦AD                                          ¦
4. Develop Scale Models       ¦BE-----------------                         ¦
                              ¦CF             (6m/m)                       ¦
                              ¦ G                                          ¦
                              ¦ H                                          ¦
                              ¦ I                                          ¦
                              ¦                                            ¦
5. Structured Survey          ¦        ------------                        ¦
                              ¦              (4m/m)                        ¦
                              ¦                                            ¦
6. Full-scale Mockups         ¦                    --------------          ¦
                              ¦                           (4m/m)           ¦
```

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
103M01	INTERIOR DESIGN GUIDELINES	06-26-85

```
                                        1987        |    1988                                 |
                                CALENDAR|O--N--D--  |J--F--M--A--M--J--J--A--S|
                                  FISCAL|FY 88                                                |
                                   MONTH|1  2  3   4  5  6  7  8  9 10 11 12|
                                 PHASE B|                                                     |
                                       C|                                                     |
STUDY TASKS                             |                                                     |
7. Mockup Reviews                       |------                                               |
                                        |  (2m/m)                                             |
                                        |                                                     |
8. Simulator Evaluation                 |   -------------                                     |
                                        |              (4m/m)                                 |
                                        |                                                     |
9. Specifications                       |                 ------                              |
                                        |                  (2m/m)                             |
                                        |                                                     |
                                        |                                                     |
                                        |TOTAL M/M = 32                                       |
```

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
103M01	INTERIOR DESIGN GUIDELINES	06-26-85

SUMMARY SCHEDULE/COST FACTORS

STUDY SPAN: Oct 85-May 88 *CM = 31

CATEGORY	FACTOR/MM(CM)*	COST $
LABOR		
- NASA Project Mgmt		
- Study Mgmt	16.0 mm	
- Study Tasks		
- Analyst, Eng'g	2.0 mm	
- Special Skills:		
Ind Design	6.0 mm	
HF, Env. Psych.	19.5 mm	
CS, Int Design	4.5 mm	
SPECIAL FACILITIES		
1-g SS Simulator	4 cm	
TRAVEL		
Coordination w/NASA, Aerospace Co's.		15 K
MATERIALS		
Mockup fabrication		10 K
TEST PROGRAM		
Test Subjects for mockup evaluation		10 K
OTHER (List)		

* MM = Manmonths; CM = Calendar Months

REPORT FORMAT 13 MANAGEMENT PLAN OVERVIEW

NUMBER	TITLE	DATE
103M02	INTERIOR LOCATION COORDINATE SYSTEM	06-27-86

ISSUE #	TITLE	NEED DATE
1030302	INTERIOR LOCATION COORDINATE SYSTEM	Dec 86

OBJECTIVES:

(01) Develop a global coordinate system for the space station entity to include all exterior structures as well as all interior and exterior module localization.

BACKGROUND:

The schematic mapping of the Space Station both intra-vehicular (IV) and extra-vehicular (EV) becomes increasingly critical as changes develop in the Space Station design towards the growth stages.

Crew sizes and missions impact module internal layouts such as the rearrangement of activity area, relocation of workstations, etc. The EV changes are from payloads and experiments accommodation and its management on the station facilities.

In both cases, the monitoring of these changes through software in data bases and schematic updating could be difficult in light of station complexity, modification/reconfiguration activities and incremental growth.

The need exists, however, to maintain an up-to-date reference system on board and for modifications to be carried out either by graphics or other means to reflect the changes in layout, workstation location, storage lockers, etc.

These location point cues tied to the reference coordinate system would minimize locational error problems by the crew and would optimize maintenance as well as servicing tasks performed to avoid potentially critical errors in realtime communication for IVA and EVA activities coordination.

This plan provides an approach to study the feasibility of developing a location coordinate system and recommendations for such a concept if it is found feasible.

INPUTS:

A. INTERIOR DESIGN GUIDELINES (Issue 1030101)
B. INTERIOR DESIGN MODIFIABILITY PROVISIONS (Issue 1030201)
C. Phase B Study Space Station configurations (by contractor)
D. COLOR, LABEL AND PATTERN CODING CRITERIA (Issue 1030301)
E. Space Station data base integration studies or plan

CRITICAL ASSUMPTIONS:

(01) Coordinate locations shall be readable by suited EMU crew members both inside and outside the station modules.

SPECIAL REMARKS:

(01) Existing design standards for color, textures, codings and labelings shall be used.

REFERENCES:

(01)

REPORT FORMAT 14 STUDY PLAN

NUMBER	TITLE	DATE
103M02	INTERIOR LOCATION COORDINATE SYSTEM	06-27-86

STUDY TASKS:

(01) Gather data from people who have used coordinate systems to include astronauts, past, and present. Elicit a preliminary evaluation and suggestions in a structured interview.

(02) Establish criteria for the optimal system, based on the information gathered in Task (01).

(03) Explore system concepts based on the criteria developed in Task 02. This could involve selection of an existing system or the development of a unique system. Evaluate each system, old or unique, on the basis of a two-dimensional drawing by returning to each of the experts or past users from Task 01. Request an initial selection or ranking.

(04) Develop a full scale model (or utilize available mock-up) which can be changed or used to evaluate the two or three optimum systems selected in Task 03. The model should allow for the relocation of items as might actually happen during SS missions.

(05) Orient different groups of naive (future) astronauts to each of the systems to be evaluated. If the system is functional, this should require very little time.

(06) Develop criteria for evaluating performance using each of the orienting systems represented in the mock-up. Orient different and naive (future) astronuats to each system and test performance against criteria that have been developed.

(07) Based on the evaluation in Task 06, select a system for verification in the SS simulator, if one is available. This evaluation should be performed by experienced astronauts.

SPECIAL STUDY NEEDS:

TASK(S)	NEED
1	NASA astronauts and NASA Center experts
4	Access to NASA simulator or mock-ups
7	NASA Laboratories and simulators

SPECIAL SKILLS:

TASK(S)	SKILL
1,2,3	Human Factors Analysts, Manned Systems Experts, Design Engineers.
4	Industrial Designers, Architects
5	NASA (future) astronauts
7	NASA astronauts

PERFORMING ORGANIZATION:

(01) Managing: NASA Level B

(02) Doing: Aerospace Firms (Prime)
Consultant astronauts &
industrial designers (Sub)

STUDY PRODUCTS:

(01) Graphic illustrations of a validated coordinate location system and recommendations for implementation.

PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS:

SUBELEMENT NO. & TITLE	Undefined Rqmt #
10303 CODING	-04

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
103M02	INTERIOR LOCATION COORDINATE SYSTEM	06-27-86

```
                                      1985      |   1986                        |
                              CALENDAR|O--N--D--|J--F--M--A--M--J--J--A--S--  |
                                FISCAL|FY 86                                   |
                                 MONTH|1  2  3   4  5  6  7  8  9  10 11 12   |
                               PHASE B|                                        |
                                     C|                                        |
STUDY  TASKS                          |                                        |
1. Survey coordinate systems          |     A thru E       ----                |
                                      |                    1 mm                |
                                      |                                        |
2. Establish criteria for system      |                       -----            |
   selection.                         |                       2 mm             |
                                      |                                        |
3. Develop system concepts for        |                           -----        |
   evaluation.                        |                           2 mm         |
                                      |                                        |
4. Develop a full scale mockup and    |                                  ------|
   evaluate selected options.         |                                   1 mm |
```

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
103M02	INTERIOR LOCATION COORDINATE SYSTEM	06-27-86

	1986			1987								
CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S
FISCAL	FY 87											
MONTH	1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												
STUDY TASKS												
5. Evaluation by astronauts.	-- .5mm											
6. Develop criteria to evaluate the system performance.		----- 3 mm										
7. Verify the selected system in the Space Station simulator.			-- .5mm									

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
103M02	INTERIOR LOCATION COORDINATE SYSTEM	06-27-86

SUMMARY SCHEDULE/COST FACTORS

STUDY SPAN: Apr 86-Dec 86 CM = 8

CATEGORY	FACTOR/MM(CM)*	COST $
LABOR		
- NASA Project Mgmt		
- Study Mgmt	5 MM	
- Study Tasks		
- Analyst, Eng'g	8 MM	
- Special Skills:		
Astronauts	1 MM	
Industrial Design Consultants	1 MM	
SPECIAL FACILITIES		
Mockups (if alternative simulator or mock-up is not available)		10 K
TRAVEL		
Coordination		2 K
MATERIALS		
Mock-up supplies (if alternative simulators or mock-ups are not available)		2 K
TEST PROGRAM		
OTHER (List)		

* MM = Manmonths; CM = Calendar Months

REPORT FORMAT 13 MANAGEMENT PLAN OVERVIEW

NUMBER	TITLE	DATE
104M01	HAB INTERIOR MATERIALS SELECTION RQMTS	06-27-85

ISSUE #	TITLE	NEED DATE
1040001	HAB INTERIOR MATERIALS SELECTION RQMTS	Jun 87

OBJECTIVES:

(01) Determine physical requirements criteria for Space Station interior materials selection and use guidelines. Rate materials by use for crew compartment suitability, safety and contamination acceptability, extended term wear characteristics and durability, and availability and cost.

BACKGROUND:

Acceptable and suitable materials for interior use in spacecraft have been shown from previous experience to be important considerations. This fact was borne out in Salyut and Skylab interior designs, particularly in the areas of decor, contamination, maintenance and safety.

Given minimum levels of physical requirements for HAB module interior materials, there still exists a wide range of uncertainty as to optimum materials for selection. All factors, including objective physical requirements of, and the subjective reactions to materials, must be considered and a consistent system of material selection must be developed. An appropriate ranking system of these factors and their relative effects with regard to materials selection must be established.

This issue resolution management plan provides the technical approach for developing the needed HAB interior materials selection requirements guidelines, with full consideration of all currently available materials as well as new materials to be developed.

INPUTS:

A. Work and living space configurations
B. ACTIVITY AREA VOLUMES (Issue 1010201)
C. Crew activities in specific locations
D. Pertinent existing public or private Materials Data Standards.

CRITICAL ASSUMPTIONS:

(01) Preliminary results from Gaseous Contaminant Load Model study by Lockheed will be available (Contract NAS8-36406, NASA-MSFC. Completion date - 7/87).

(02) Phase C/D will begin 3rd quarter FY '87.

SPECIAL REMARKS:

(01) It should be recognized that certain difficulties arise in the comparison of hard, objective data on considerations such as strength/weight ratios, abrasion resistance, hardness, etc., and data regarding subjective considerations such as color, tactile quality, etc. The purpose of this study is to focus on physical requirements only.

(02) Aesthetic requirements will be addressed in coordination with the completion of Management Plan 103M01 INTERIOR DESIGN GUIDELINES (end of Task 4, March '87).

REFERENCES:

(01) NASA-MSFC, Gaseous Contaminant Load Model, Contract NAS8-36406, Alabama.

REPORT FORMAT 14 STUDY PLAN

NUMBER	TITLE	DATE
104M01	HAB INTERIOR MATERIALS SELECTION RQMTS	06-27-85

STUDY TASKS:

(01) Identify and analyze any current standards (or practices) that govern interior material selection for spacecraft interiors as developed by NASA, incorporating Skylab, Orbiter, etc.

(02) Identify leading experts in materials manufacture and specialized use who can provide expertise on interior materials for which no current standards exist.

(03) Consult with these experts to obtain missing data and projections for new materials which might be in the developmental process.

(04) Gather data from previous non-spacecraft interior materials applications with analogous requirements (aircraft, submarines, etc.).

(05) Using available data, and in consultation with identified experts, determine acceptable physical requirements for materials to be used in space station interiors. These guidelines will take into account preliminary data (final, if available) from the Gaseous Contamination Model (1).

(06) Develop Interior Material Standards Guidelines for existing and projected new material prior to the beginning of Phase C/D.

(07) Incorporate aesthetic judgments from Interior Design Guidelines (output of Management Plan 103M01) to create Interior Materials Selection Requirements to be used by Space Station design personnel.

SPECIAL STUDY NEEDS:

TASK(S)	NEED

SPECIAL SKILLS:

TASK(S)	SKILL
1,2	Materials Manufacturers

PERFORMING ORGANIZATION:

(01) Managing: NASA Level B

(02) Doing: Aerospace Firms (Prime)
Consultants (Sub)

STUDY PRODUCTS:

(01) Interior Materials Standards Guidelines

(02) Interior Materials Selection Requirements

PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS:

SUBELEMENT NO. & TITLE	Undefined Rqmt #
10400 MATERIALS	-01

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
104M01	HAB INTERIOR MATERIALS SELECTION RQMTS	06-27-85

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                                     1985         ¦    1986                            ¦
                             CALENDAR¦O--N--D--¦J--F--M--A--M--J--J--A--S--¦
                               FISCAL¦FY 86                                      ¦
                                MONTH¦1  2  3   4  5  6  7  8  9  10 11 12 ¦
                              PHASE B¦                                            ¦
                                    C¦                                            ¦
STUDY  TASKS                         ¦                                            ¦
Assumes Phase C/D start date 3rd     ¦                                            ¦
quarter, FY '87                      ¦                                            ¦
1.  Analyze current standards        ¦                 D ----------               ¦
                                     ¦                      3 mm                  ¦
                                     ¦                                            ¦
2. Identify experts                  ¦                       ------               ¦
                                     ¦                        1 mm                ¦
                                     ¦                                            ¦
3. Consult with experts              ¦                              -----         ¦
                                     ¦                              2 mm          ¦
                                     ¦                                            ¦
4. Research non-spacecraft           ¦                                 ------¦
   applications                      ¦                                  2 mm ¦
```

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
104M01	HAB INTERIOR MATERIALS SELECTION RQMTS	06-27-85

```
                                          1986       |   1987                              |
                                  CALENDAR|O--N--D--|J--F--M--A--M--J--J--A--S--|
                                    FISCAL|FY 87                                         |
                                     MONTH|1  2  3   4  5  6  7  8  9  10 11 12 |
                                   PHASE B|                                              |
                                         C|                                              |
STUDY  TASKS                              |                                              |
5. Determine physical requirements        |-------                                       |
                                          |  2 mm                                        |
                                          |                                              |
6. Develop Interior Materials             |       ------                                 |
   Standards Guidelines                   |        1 mm                                  |
                                          |                                              |
7. Develop Interior Materials             |           A  ---------                       |
   Selection Requirements                 |           B     3 mm                         |
                                          |           C                                  |
                                          |                                              |
                                          |                                              |
```

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
104M01	HAB INTERIOR MATERIALS SELECTION RQMTS	06-27-85

SUMMARY SCHEDULE/COST FACTORS

STUDY SPAN: Apr 86-Apr 87 CM = 13

CATEGORY	FACTOR/MM(CM)*	COST $
LABOR		
- NASA Project Mgmt	5 MM	
- Study Mgmt		
- Study Tasks		
- Analyst, Eng'g	11 MM	
- Special Skills: Materials Experts	3 MM	
SPECIAL FACILITIES		
TRAVEL		10 K
MATERIALS		
TEST PROGRAM		
OTHER (List)		

MMs = 14

* MM = Manmonths; CM = Calendar Months

REPORT FORMAT 13 MANAGEMENT PLAN OVERVIEW

NUMBER	TITLE	DATE
105M01	ANTHROPOMETRIC DATA DEVELOPMENT	06-26-85

ISSUE #	TITLE	NEED DATE
1050201	ANTHROPOMETRIC RANGE ACCOMMODATIONS	Dec 86
1050301	NEUTRAL BODY POSTURE DATA DEVELOPMENT	
1050401	GROWTH AND ANTHROPOMETRIC CRITERIA	

OBJECTIVES:

(01) To determine the outer anthropometric population limits for space station.

(02) To project 30-year anthropometric growth trends.

(03) To develop anthropometrics for neutral body posture.

BACKGROUND:

The size and strength of a person doing a particular task must meet the requirements of the task if it is to be performed adequately. While, in some cases, the task is structured and the person must be selected to suit the task, in other instances the task can be designed to accommodate a range of sizes and strengths. The latter more closely approximates the ideal situation and is illustrated in Figure 1.

A considerable body of anthropometric data already exists, including anthropometrics in "weightlessness" (1). This data should serve as a necessary starting point for making preliminary or tentative decisions. The purpose of this management plan is to provide a structure for determining the additional data needs and the framework for that data which must be acquired by what points in time in order to meet design requirements.

INPUTS:

A. None

CRITICAL ASSUMPTIONS:

(01) That some anthropometric limits must be defined by the beginning of Phase C/D.

(02) Phase C/D will begin 3rd quarter, FY '87.

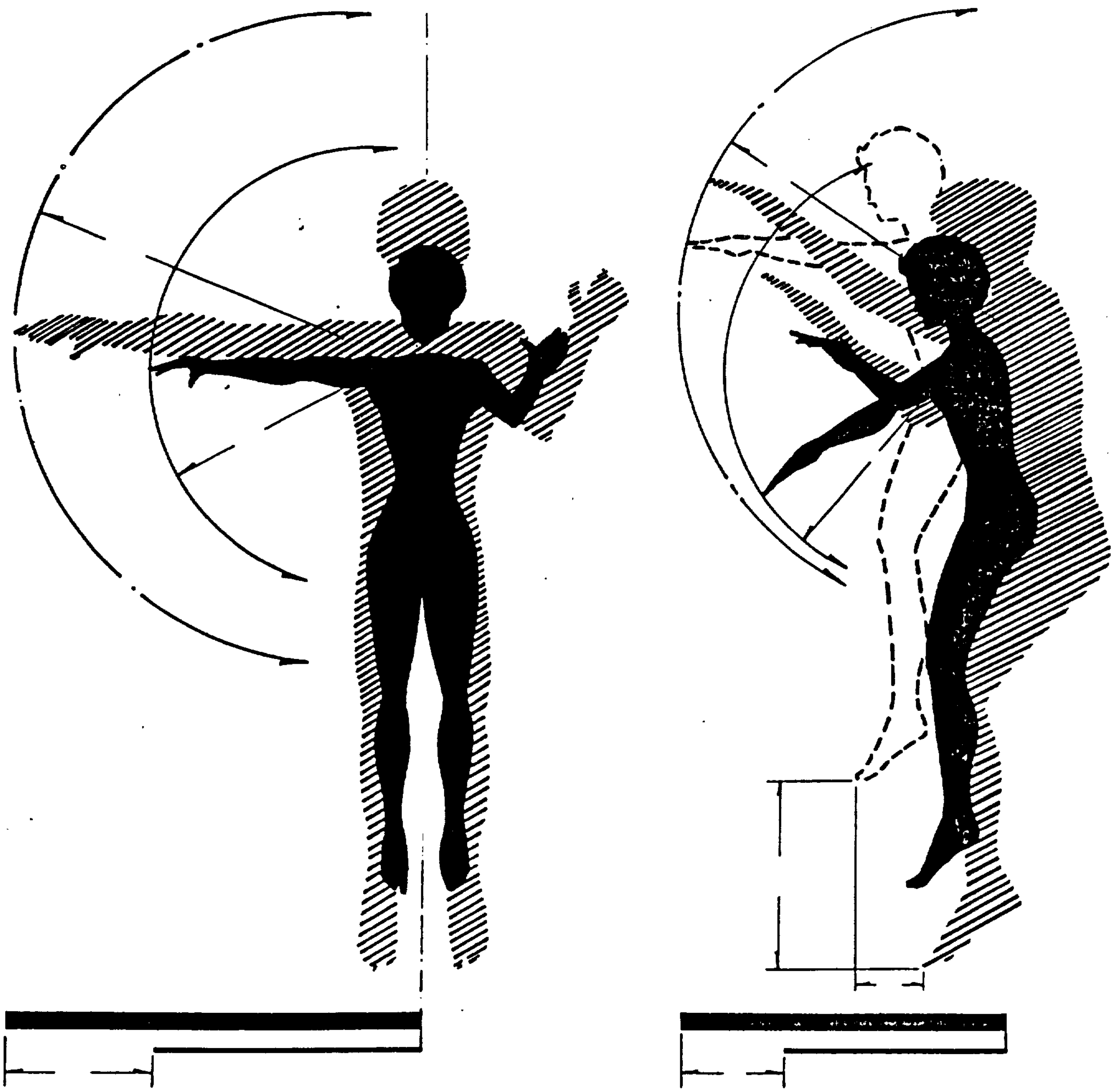

Figure 1. Fifth percentile American female and fifth percentile American male.

SPECIAL REMARKS:

(01) The scope of this study is confined to expert opinion because of time constraints and the need for early information.

(02) The need to validate the decisions made as a result of the present study should dictate continued research. Minor adjustments to data, curves, etc., over time are a possibility.

REFERENCES:

(01) NASA, Anthropometric Source Book Vol. I (Vols II, III): A Handbook of Anthropometric Data, Reference Publication 1024, NASA Scientific and Technical Information Office, 1978.

REPORT FORMAT 14 STUDY PLAN

NUMBER	TITLE	DATE
105M01	ANTHROPOMETRIC DATA DEVELOPMENT	06-26-85

STUDY TASKS:

(01) Update anthropometric data, extrapolate and project 30-year growth curves.

a. Identify expert anthropometrists, including a NASA representative

b. Convene panel to define population to be considered, i.e., what is the operational definition of the 5th percentile oriental female. Select key body points to be used.

c. Independently, panel members will collect and evaluate published data. They will also identify sources of current data generation; acquire and evaluate it. (1)

d. Reconvene panel members who will make predictions and draw 30 year projection curves.

e. Prepare a draft report which will satisfy the population anthropometrics for design and the 30-year growth trends.

(02) Develop zero-g anthropometric guidelines.

a. Using experts defined in task one, select key body points from which to take measurements of change, if necessary.

b. Review published data and new, unpublished data, if available.

c. Recommend further data collection and provide the design for doing so, if this is necessary.

d. Provide NASA with preliminary information.

(03) Prepare draft final report for review, incorporating the results of Tasks 1 and 2. Revise, produce final report.

SPECIAL STUDY NEEDS:

TASK(S)	NEED
1,2	Conference space at NASA, JSC
1,2	Access to all anthropometric data being collected by NASA or under contract to NASA.

SPECIAL SKILLS:

TASK(S)	SKILL
1,2	Demonstrated anthropometric expertise

PERFORMING ORGANIZATION:

(01) Managing: NASA, JSC, Manned Systems Division

(02) Doing: Aerospace or Consulting Firm (Prime)
Consultants (Sub)

STUDY PRODUCTS:

(01) Anthropometric guidelines

PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS:

SUBELEMENT NO. & TITLE		Undefined Rqmt #
10502	RANGE OF ACCOMMODATION	-01,-02,-03
10501	ANTHROPOMETRY	-01
10503	PHYSICAL DIMENSIONS IN MICRO-G	-03
10504	GROWTH	-01

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
105M01	ANTHROPOMETRIC DATA DEVELOPMENT	06-26-85

	1985			1986								
CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S
FISCAL	FY 86											
MONTH	1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												

STUDY TASKS	Schedule
Phase C/D will begin 3rd quarter, FY '87.	
1. Update anthropometric data, etc.	Months 1–9: 18 mm
2. Develop zero-g anthropometric guidelines.	Months 4–12: 8 mm

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
105M01	ANTHROPOMETRIC DATA DEVELOPMENT	06-26-85

	1986			1987								
CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S
FISCAL	FY 87											
MONTH	1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												
STUDY TASKS												
2. (cont)	--------- 4mm											
3. Final Report		------- 3 mm										

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
105M01	ANTHROPOMETRIC DATA DEVELOPMENT	06-26-85

SUMMARY SCHEDULE/COST FACTORS

STUDY SPAN: Oct 85-Dec 86 CM = 14

CATEGORY	FACTOR/MM(CM)*	COST $
LABOR		
- NASA Project Mgmt	3 MM	
- Study Mgmt		
- Study Tasks		
- Analyst, Eng'g	4 MM	
- Special Skills:	29 MM	
SPECIAL FACILITIES		
Conference space at NASA, JSC		
TRAVEL		
Convening expert panel at NASA, JSC		50 K
MATERIALS		None
TEST PROGRAM		None
OTHER (List)		None
	MMs = 33	

* MM = Manmonths; CM = Calendar Months

REPORT FORMAT 13 MANAGEMENT PLAN OVERVIEW

NUMBER	TITLE	DATE
106M01	INTERIOR VOLUME REARRANGEMENT REQUIREMENTS	6-28-85

ISSUE #	TITLE	NEED DATE
1060101	INTERIOR VOLUME REARRANGEMENT REQUIREMENTS	Jun 86

OBJECTIVES:

(01) Determine the requirements for how Space Station personnel shall be able to modify interior room arrangements to accommodate changing mission needs.

(02) Determine equipment requirements that ensure flexibility to reconfigure in various module configurations.

BACKGROUND:

Space or volume within a facility should be allocated according to the functions to be performed. Because the overall efficiency of Space Station activity depends on an optimum allocation of volume to function, the capability to change volumetric arrangements will be necessary as the scientific, technical and personnel requirements change. For Space Station, the capability for major structural revision is far less feasible than it is for an earthbound facility. Moreover, because of the high premium on Space Station personnel's time and the remoteness of resources, even minor structural changes must be limited. Provisions must be made for making the the changes as efficient as possible.

This issue resolution study is for an analysis of the known scientific, technical, personnel and manufacturing requirements to identify the equipment, furnishings, personnel and volumetric accommodations which will be needed for the various functions. This analysis will provide the basis for determination of the hardware design requirements for the room dividers and their means of attachment. To ensure the goal of commonality, the provisions for the individual volume changes will need to be incorporated in the common module design features.

INPUTS:

A. Phase B study data including present and future mission scenarios.
B. Preliminary specifications of equipment, furnishings and utilities planned for support of Space Station activities.
C. Preliminary basic configuration layouts and mockups.
D. Anticipated growth configurations.
E. ACTIVITY AREA VOLUMES (Management Plan 101M01)
F. MODULE/ACTIVITY AREA ORIENTATION STANDARD (Management Plan 101M01)
G. STANDARD HARDWARE AND INTERFACE REQMTS (Management Plan 106M02)

CRITICAL ASSUMPTIONS:

(01) Future mission scenarios will be available in time and at a level of detail to enable determination of personnel and equipment requirements.

(02) Space Station mission development will be sufficiently predictable to enable systematic analysis of volume and equipment requirements.

(03) Results of Management Plan 106M02, STANDARD HARDWARE AND INTERFACE REQUIREMENTS, will be available in time to support this study.

SPECIAL REMARKS:

(01) While the overall approach of this plan is analytic, generalizations drawn from other systems will be evaluated for applicability.

(02) A critical input for this study will be the results of STANDARD HARDWARE AND INTERFACE REQUIREMENTS (Management Plan 106M02).

(03) Minimizing the crew workload is a primary criteria in the selection of alternative volume rearrangement approaches.

(04) Reference 1 should be referred to when conducting this study.

(05) This study must take into account that room partitions may have to be moved by an EMU-suited crewmember to provide for EVA access to repair cabin wall leaks and/or ECLSS.

REFERENCES:

(01) Boeing Aerospace Co., D180-28402-1, "Space Station Habitability Design Recommendations". Vol. 1, Nov 1984

REPORT FORMAT 14 STUDY PLAN

NUMBER	TITLE	DATE
106M01	INTERIOR VOLUME REARRANGEMENT REQUIREMENTS	6-28-85

STUDY TASKS:

(01) Review Space Station Operations - Review Space Station operations and Phase B study data to identify scope of volumetric change requirements. Consult with NASA mission operations and equipment experts and examine mission mockups. Because of anticipated softness of data, there will be extensive reliance on expert judgement.

(02) Define Volume Requirements - Define volume, arrangement, and modularity requirements for each set of mission requirements. Review with mission, operations and equipment experts.

(03) Identify Volumetric Division Interfaces - Analyze requirements from Task 2 to identify necessary divider interfaces to accommodate necessary reconfigurations. Take into account EMU-suited crewmember performing the reconfigurations.

SPECIAL STUDY NEEDS:

TASK(S)	NEED
1	Langley data base, Phase B study data, access to NASA mission/operations and equipment experts.
2	Access to NASA mission/operations and equipment experts.
3	Access to mockups of the various mission modules.

SPECIAL SKILLS:

TASK(S)	SKILL
1,2	System/task Analysis Specialists
3	Interior workstation designers, and time and motion specialist

PERFORMING ORGANIZATION:

(01) Managing: NASA-JSC, Level B

(02) Doing: Aerospace Firms (WP-01 and WP-02)

STUDY PRODUCTS:

Detailed design specifications for:

(01) Potential interior volume rearrangements.

(02) Number, location and configuration requirements for equipment/utility/wall divider interfaces needed interfaces needed to support alternative equipment locations/configurations.

<u>PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS</u>:

SUBELEMENT NO. & TITLE		Undefined Rqmt #
10603	Modularity - EXISTING STANDARDS AND CONVENTIONS	-01
10601	Modularity - GENERAL	-01

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
106M01	INTERIOR VOLUME REARRANGEMENT REQUIREMENTS	6-28-85

	1985			1986								
CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S
FISCAL	FY 86											
MONTH	1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												

STUDY TASKS	
Assumes SRR March 1986	A B C D E F G
1. Review Space Station Operations	---------- (4 mm)
2. Devine Volume Requirements	-------- (3 mm)
3. Identify Volumetric Divisions Interfaces	------ (2 mm)

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
106M01	INTERIOR VOLUME REARRANGEMENT REQUIREMENTS	6-28-85

SUMMARY SCHEDULE/COST FACTORS

STUDY SPAN: OCT 85-MAR 86 CM = 5

CATEGORY	FACTOR/MM(CM)*	COST $
LABOR		
- NASA Project Mgmt		
- Study Mgmt	4 MM	
- Study Tasks		
- Analyst, Eng'g	7 MM	
- Special Skills:		
- Interior Design	1 MM	
- Time and Motion	1 MM	
SPECIAL FACILITIES		
TRAVEL		
- Coordination with NASA		2 K
MATERIALS		
TEST PROGRAM		
OTHER (List)		

* MM = Manmonths; CM = Calendar Months

REPORT FORMAT 13 MANAGEMENT PLAN OVERVIEW

NUMBER	TITLE	DATE
106M02	STANDARD HARDWARE AND INTERFACE REQMTS.	6-26-85

ISSUE #	TITLE	NEED DATE
1060102	STANDARD HARDWARE AND INTERFACE REQMTS	Mar 86

OBJECTIVES:

(01) Determine the requirements for interface design standardization within the Space Station using a minimum of human involvement in repair, maintenance, reconfiguration, etc. as a criterion. These requirements will provide the basis for development of standards for primary and secondary structural interfaces, sub-system attachment interfaces, and utility interfaces such as electrical, cooling, data buses, etc. and, for standardized fasteners, latches, tools, and packaging.

(02) Determine the requirements for commonality of fasteners, latches, packaging, tools, etc. from the standpoint of a minimum of human involvement.

BACKGROUND:

Standardizatioin of structural and subsystem interfaces is of primary importance in the Space Station Program (Ref. 01). The benefits of standardization include the following: 1) reduces the number of orbital replacement units, 2) reduces the number of tools, and 3) simplifies maintenance, repair, and reconfiguration operations. All of these factors reduce cost.

This issue resolution study will focus on optimization of this design aspect considered from the human productivity point of view. This study will include an analysis of the scope of human involvement in physical manipulation of components, subsystems and secondary structure involved in maintenance, repair and reconfiguration of the internal systems and structures of the various Space Station modules. This analysis will be facilitated by development of a computer aided commonality analysis methodology which is currently in progress. (Ref. 2)

INPUTS:

A. List of Space Station operations (Mission data) and their operational flow, i.e., Langley Data Base.
B. Number and extent of revised configurations to be accommodated.
C. Anticipated growth configurations.
D. INTERIOR VOLUME REARRANGEMENT REQUIREMENTS (Management Plan 106M01).

CRITICAL ASSUMPTIONS:

(01) Commonality and standaridization requirements will not differ from a one-g context and can thus be derived and validated by one-g experience guided by known zero-g relationships.

SPECIAL REMARKS:

(01) The results of this study will be a critical input to the commonality analysis study (Ref. 2).

(02) The results of this study will be a critical input to the INTER IOR VOLUME REARRANGEMENT REQUIREMENTS Study (Management Plan 106M01).

(03) This study must consider the impact of an EMU-suited crewmember having to manipulate the hardware during damage repair.

REFERENCES:

(01) NASA Solicitaion #9-BF-10-4-01P, "Space Station Definition and Preliminary Design, Request for Proposal", Sept. 1984

(02) Space Station Commonality Analysis, Contract NAS8-36413, April 1985

REPORT FORMAT 14 STUDY PLAN

NUMBER	TITLE	DATE
106M02	STANDARD HARDWARE AND INTERFACE REQMTS.	6-26-85

STUDY TASKS:

(01) Identify Hardware and Interface Standardization Areas - Identify IVA hardware for interface areas for which standard design requirements are needed. This task will involve examination of existing hardware and human interfaces at the Orbital Replacement level (ORU) for Skylab, Spacelab and Shuttle and evaluating their suitability for Space Station application.

(02) Review/Analyze Standardization Data - Perform task analyses to define the crew tasks and tools involved in performing representative maintenance, repair, and reconfiguration functions. Take into account that some repair tasks may have to be done in an unpressurized mode by an EMU-suited crewmember. Apply the lessons learned from Task 01.

(03) Develop Requirements for Standardization - Develop requirements for standardization of IVA system, hardware, software and human interface design. These requirements will include representative design solutions, where needed.

SPECIAL STUDY NEEDS:

TASK(S)	NEED
1	Engineering Drawings for Spacelab, Skylab and Space Shuttle.
2	Commercial and Military Standards Documents

SPECIAL SKILLS:

TASK(S)	SKILL
1	Engineering Analyst/aid Skill
2	Industrial Designer/Human Factors Engineer
3	Industrial Designer/Engineer

PERFORMING ORGANIZATION:

(01) Managing: NASA - Level B

(02) Doing: Aerospace Firms (WP-01 and WP-02)

STUDY PRODUCTS:

Detailed design specifications for:

(01) Standardized structural and functional ORU components/interfaces which simplify personnel interaction involvement.

(02) Standardized fasteners, latches, tools and packaging.

PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS:

SUBELEMENT NO. & TITLE		Undefined Rqmt #
10601	Modularity - GENERAL	-02
10603	EXISTING STANDARDS AND CONVENTIONS	-03
10607	Modularity - GROWTH	-01,-03

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
106M02	STANDARD HARDWARE AND INTERFACE REQMTS.	6-26-85

```
                                         1985      |    1986                            |
                                CALENDAR|O--N--D--|J--F--M--A--M--J--J--A--S--|
                                  FISCAL|FY 86                                         |
                                   MONTH|1  2  3   4  5  6  7  8  9  10 11 12 |
                                 PHASE B|                                              |
                                       C|                                              |
STUDY  TASKS                            |                                              |
Assumes SRR March, 1986                 |A                                             |
                                        |B                                             |
                                        |C                                             |
                                        |D                                             |
1. Identify Hardware and Interface      |------                                        |
   Standardization Areas                |(4 mm)                                        |
2. Review and Analyze Standardization   |   ------                                     |
   Data                                 |   (3 mm)                                     |
3. Develop Requirements for             |          ------                              |
   Standardization                      |          (4 mm)                              |
                                        |                                              |
```

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
106M02	STANDARD HARDWARE AND INTERFACE REQMTS.	6-26-85

SUMMARY SCHEDULE/COST FACTORS

STUDY SPAN: OCT 85-MAR 86 CM = 5

CATEGORY	FACTOR/MM(CM)*	COST $
LABOR		
- NASA Project Mgmt		
- Study Mgmt	3 MM	
- Study Tasks		
- Analyst, Eng'g	11 MM	
- Special Skills:		

SPECIAL FACILITIES

TRAVEL

MATERIALS

TEST PROGRAM

OTHER (List)

* MM = Manmonths; CM = Calendar Months

REPORT FORMAT 13 MANAGEMENT PLAN OVERVIEW

NUMBER	TITLE	DATE
109M01	EQUIPMENT AND FOOD STORAGE	06-22-85

ISSUE #	TITLE	NEED DATE
1090101	STOWAGE CONFIGURATION	Jul 87
1090601	STOWAGE VOLUME & CONFIGURATION REQUIREMENTS FOR GROWTH	Jul 87

OBJECTIVES:

(01) To define the optimal stowage configuration in terms of volume, layout, inventory control, accessibility of stowed items, and interchangeability of stowage compartments/containers used for stowing items such as recreational equipment, crew equipment, galley equipment, food, dishes, clothing, personal hygiene provisions, and workstation/ancillary provisions.

(02) And to determine additional stowage volume/configurations to provide for Space Station growth.

BACKGROUND:

Stowage method and location will have profound effect on Human Productivity in terms of resupply, stowage efficiency and crew time. Certain requirements for stowage on the Space Station are similar to those of the Space Shuttle and Skylab programs.

Crew equipment onboard the Shuttle is packed in trays which are inserted into lockers. The trays are adaptable to accomodate a wide variety of softgoods, hardware, loose equipment and food. The storage lockers are interchangeable, can be removed or installed in flight by crewmembers, and are attached to the bulkhead with a screw fitting. The lockers are made of light weight reinforced composite material. The locker dimensions are approximately 10 X 17 X 20 inches, contain 2 cubic feet of stowage volume and can hold up to 60 pounds (04).

Stowage areas in the Space Shuttle Obiter for the crew compartment are located in the forward flight deck, the aft flight deck, the mid-deck, the equipment bay, and the airlock module. In the aft flight deck, stowage lockers are located below the rear payload control panels in the center of the deck. Lockers can be mounted to the right and left of the payload control station. Lockers are interchangeable thereby providing flexibility for varying payloads and mission requirements. Crew flight equipment, flight safety equipment, emergency kits and survival equipment are stowed in the forward flight deck. In the mid-deck, lockers are attached in the forward avionics bay and the area can accommodate thirty-three lockers (04).

Stowage lockers on board the Skylab were considered structurally identical, except that standard lockers had a maximum content weight limitation of 200 pounds each, while galley lockers had a weight

limitation of 92 pounds each. The structural configuration of the galley stowage lockers was similar to that of the standard locker (02).

The short-comings in the Skylab and Space Shuttle stowage areas were the identification, inventory control, and restraints created for equipment and food stowage onboard. The greatest problem was incorrect and unrecorded restowage by crewmembers. This made it difficult to assess inventory and to locate items quickly. Crew reports indicate that like items should be stowed together in the same area of the spacecraft. Stowage areas were not always identified clearly. Some food packages stowed in various temperature-regulated compartments were inadequately restrained.

INPUTS:

(A) Space Station Reference Configuration.

(B) Phase B Contract Study Reports (Stowage Analysis).

(C) SSP Subsystem Study Reports (Stowage).

(D) Predicted Space Station Growth rates.

(E) Volumes of stowable equipment per crewmember.

(F) Issue 2140201 (INVENTORY MANAGEMENT SYSTEM DEVELOPMENT)

(G) Issue 1040001 (Habitability interior materials selection requirements)

CRITICAL ASSUMPTIONS:

(01) Generic stowage provisions will suffice for planning purposes through SDR since detailed design is paced by equipment definition.

SPECIAL REMARKS:

(01) Maintain contact with all Phase B contractors and associated study contractors.

(02) Tasks will be facilitated by input from Issue 2140201 (INVENTORY MANAGEMENT SYSTEM DEVELOPMENT).

REFERENCES:

(01) JSC-09989, "Space Station Reference Configuration Description, "Systems Engineering and Integration-Space Station Program Office, Johnson Space Center, Aug. 1984.

(02) T74-16081, "Lessons Learned on the Skylab Program", Johnson Space Center, July 18, 1974.

(03) Boeing Aerospace Co., D180-26495-1, "Space Operations Center Systems Analysis, Vol. III", July 1981.

(04) 723-000/562 "Shuttle News Reference", NASA 1981.

REPORT FORMAT 14 STUDY PLAN

NUMBER	TITLE	DATE
109M01	EQUIPMENT AND FOOD STORAGE	06-22-85

STUDY TASKS:

(01) Perform literature review to identify potentially viable Space Station storage provisions. A subtask will be to analyze and evaluate mission results and program reports of the Mercury, Gemini, Apollo, Soyuz, Salyut, Skylab and Shuttle programs in the area of storage. Problem areas and failures of the various storage systems will be identified. Another subtask will be to review NASA/Contractor reports on proposed Space Station storage systems and to identify potentially viable alternatives. Areas requiring additional research or technology advancement will be identified.

(02) Define types/categories of food and crew equipment requiring stowage on Space Station based on current program documentation. Identify constraints which will have an impact on size, configuration, material composition and location of various stowage compartments. Constraints such as volume allocation per equipment category, (e.g., clothing, frozen food, hygiene aids, safe haven) will be utilized to drive the selection of a baseline storage system.

(03) Perform trade studies on the previously identified system alternatives to arrive at a baseline equipment and food storage system. Key trades will include: localized vs. centralized equipment stowage, bulk stowage vs. individual; open restraints vs. enclosure system; resupply intervals vs. storage volume allocations.

(04) Determine the requirements for additional stowage volume with Space Station growth. To determine the additional stowage volume required per crewmember, the available volume of all stowable equipment per crewmember must be known along with predicted Space Station growth rates.

(05) Determine the optimum location for stowage compartments within the various habitable areas of the Space Station. Key factors will be the interior module configuration and traffic patterns, the equipment and food accessibility, and work station locations.

(06) Formulate requirements and specifications for a Space Station stowage system. Options for design configurations, material composition, quantities and location of various stowage containers will be included.

SPECIAL STUDY NEEDS:

TASK(S)	NEED
	None identified.

SPECIAL SKILLS:

TASK(S)	SKILL
	None identified.

PERFORMING ORGANIZATION:

(01) Managing: NASA,JSC-MSD

(02) Doing: Aerospace Firms (Prime)

STUDY PRODUCTS:

(01) Baseline stowage system and configurations.

(02) Modification of baseline necessary for growth of SSP.

(03) Stowage system requirements and specifications.

PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS:

SUBELEMENT NO. & TITLE	Undefined Rqmt #
10901 CREW EQUIPMENT STOWAGE	-01 THRU -05, -09, -20
10906 STOWAGE/STORAGE	-01

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
109M01	EQUIPMENT AND FOOD STORAGE	06-22-85

	1984			1985								
CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S
FISCAL	FY 85											
MONTH	1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												
STUDY TASKS												
1. Perform Literature Review												--

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
109M01	EQUIPMENT AND FOOD STORAGE	06-22-85

```
                                     1985        |    1986                                  |
                             CALENDAR|O--N--D--|J--F--M--A--M--J--J--A--S|
                               FISCAL|FY 86                                                 |
                                MONTH|1  2  3    4  5  6  7  8  9 10 11 12|
                              PHASE B|                                                      |
                                    C|                                                      |
STUDY  TASKS                         |                                                      |
1.  Perform Literature Review        |--                                                    |
                                     |(2 mm)                                                |
                                     |                                                      |
2.  Identify Items which are stowed  |       --------                                       |
                                     |        (3 mm)                                        |
                                     |                                                      |
3.  Perform Trade Studies            |           ----------------------                     |
                                     |                                                      |
                                     |                                                      |
4.  Determine Additional Stowage     |                      B,C -------                     |
    Required for Growth              |                      D,E (3 mm)                      |
                                     |                                                      |
5.  Determine Locations              |            ---------------------                     |
                                     |                   (8 mm)                             |
                                     |                                                      |
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REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
109M01	EQUIPMENT AND FOOD STORAGE	06-22-85

```
                                        1986        |    1987               |
                                CALENDAR|O--N--D--|J--F--M--A--M--J--J--A--S|
                                  FISCAL|FY 87                               |
                                   MONTH|1  2  3   4  5  6  7  8  9 10 11 12|
                                 PHASE B|                                    |
                                       C|                                    |
STUDY  TASKS                            |                                    |
3.  Perform Trade Studies               |----------                          |
    (cont.)                             |  (9 mm)                            |
                                        |                                    |
4.  Determine Additional Stowage        |----------                          |
    Required for Growth                 |  (3 mm)                            |
    (cont.)                             |                                    |
                                        |                                    |
6.  Formulate Requirements              |          F,G -----------           |
                                        |               (4 mm)               |
```

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
109M01	EQUIPMENT AND FOOD STORAGE	06-22-85

SUMMARY SCHEDULE/COST FACTORS

STUDY SPAN: JUL 85-JAN 87 CM = 13

CATEGORY	FACTOR/MM(CM)*	COST $
LABOR		
- NASA Project Mgmt	3 MM	
- Study Mgmt		
- Study Tasks		
- Analyst, Eng'g	24 MM	
- Special Skills:		
SPECIAL FACILITIES		
TRAVEL Travel to NASA and Contractor Centers for design and configuration reviews.		4 K
MATERIALS Mock-up fabrication of stowage containers		5 K
TEST PROGRAM o Inventory Management Evaluation o Evaluation of mock-up configurations		10 K
OTHER (List)		

* MM = Manmonths; CM = Calendar Months

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REPORT FORMAT 13 MANAGEMENT PLAN OVERVIEW

NUMBER	TITLE	DATE
109M02	DATA FILE STOWAGE REQUIREMENTS	06/23/85

ISSUE #	TITLE	NEED DATE
1090401	DATA FILE STOWAGE REQUIREMENTS	NOV 1987

OBJECTIVES:

(01) To define stowage provisions required for safe and efficient stowage of Flight Data File (FDF) items.

(02) And to formulate requirements and specifications for Flight Data File stowage equipment.

BACKGROUND:

The Flight Data File is a flight reference data file that is readily available to crewmembers. It consists of an onboard complement of documentation and related crew aids and includes:

(1) Documentation such as procedural checklists (normal, backup, and emergency procedures), malfunction procedures, crew activity plans, schematics, photographs, cue cards, star charts, earth maps, and crew notebooks.

(2) Storage containers; and

(3) Ancillary equipment such as tethers, clips, tape, and erasers.

Packaging and stowage of Shuttle Orbiter Flight Data Files are accomplished on an individual flight basis. Flight data file items are currently stowed in five types of stowage containers. They include lockers, the flight deck module, the commander's and pilot's seat back FDF assemblies, the mid-deck FDF assembly, and the map bag. The portable containers are stowed in a mid-deck modular locker for launch and entry. If the flight carries a Spacelab Module, all Spacelab books are stowed for launch in a portable container on the mid-deck and transferred inflight to a location in the Spacelab (2). In all the foregoing, rapid accessability is important to mission success and human productivity.

INPUTS:

A. SSP Reference Documents (Data Management System Definition).

B. Space Station Analogs (data file stowage on submarines, aircraft, etc.).

C. Preliminary Module Layouts (stowage allocations).

D. Data Management Systems Analysis, WP-02, Phase B Study.

E. Equipment and Food Storage Volume Allocations (Subelement 10901).

CRITICAL ASSUMPTIONS:

(01) All critical Space Station experiments and flight operation functions will be supported by hard copies of detailed procedures.

(02) Each Space Station module will have its own FDF stowage provisions.

(03) Safe Haven provisions will include stowage for FDF items such as malfunction procedures and emergency procedures.

(04) Data inputs from A, B, and C will be available by ISR.

(05) Data input from D will be available by SDR.

SPECIAL REMARKS:

(01) Computers will play a vital role in Data Management and therefore the potential need for stowage of computer hardware and software will be considered. (1)

(02) The present study will only address FDF requirements for the Space Station Initial Operational Capability. As mission scenarios change over time, the flight data file requirements will be updated.

REFERENCES:

(01) JSC-19989, "Space Station Reference Configuration Description", NASA-JSC, August 1984.

(02) 723-000/562, "Space Shuttle News Reference", NASA, 1981.

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REPORT FORMAT 14 STUDY PLAN

NUMBER	TITLE	DATE
109M02	DATA FILE STOWAGE REQUIREMENTS	06/23/85

STUDY TASKS:

(01) Perform literature review to identify candidate FDF items and methods/equipment for stowing them. Subtasks will be the identification of FDF items stowed on previous manned missions and the methods by which they were stowed. To accomplish this, it will be necessary to analyze and evaluate mission results and program reports of the Mercury, Gemini, Apollo, Soyuz, Salyut, Skylab and Shuttle programs in the area of FDF stowage. In addition, it will be necessary to review SSP reference documentation and Space Station analogs (e.g., nuclear submarines) in order to identify candidate FDF items and requirements for FDF stowage.

(02) Perform trade studies to determine which candidate Space Station FDF items will be stored on-orbit. Key trades will include: on-orbit storage of data vs. data uplinked from the ground; hard copy data vs. data stored in computer memory systems.

(03) Identify FDF items which require unique storage provisions and requirements (e.g. temperature control, humidity control, radiation shielding). FDF items such as photographs may require low humidity storage while other items such as computer floppy disks may require radiation shielding.

(04) Trade-off alternative methods for storing flight FDF items. Key trades will include: hard containers vs. soft containers; portable containers vs. fixed containers; centralized stowage vs. localized stowage; and retrieval methods.

(05) Formulate requirements and specifications for FDF stowage compartments. These requirements and specifications will include materials selection, configuration, access and retrieval, inventory control equipment, environmental control parameters, quantities, and recommended locations within the Space Station modules.

SPECIAL STUDY NEEDS:

TASK(S)	NEED
02	Access to NASA and Contractor Data Management experts.

SPECIAL SKILLS:

TASK(S)	SKILL
	None Identified.

PERFORMING ORGANIZATION:

MANAGING: NASA, JSC-MSD
DOING: Aerospace Firms (Prime)

STUDY PRODUCTS:

(01) A comprehensive list of FDF items which must be stored on-orbit.

(02) Design requirements and specifications for FDF stowage provisions.

PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS:

SUBELEMENT NO. & TITLE	Undefined Rqmt #
10904 Data File Stowage	-01, -02

REPORT FORMAT 13 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
109M02	DATA FILE STOWAGE REQUIREMENTS	06/23/85

	1986			1987								
CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S
FISCAL	FY 87											
MONTH	1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												
STUDY TASKS												
1. Perform Literature Review	A ------ (3m/m)	------	------									
	B											
2. Perform Trade Studies				C	------	------ (4 m/m)	------					
3. Identify Unique Stowage Rqts.									------ (2 m/m)	------		
4. Formulate Requirements & Specs.										------	------	------

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
109M02	DATA FILE STOWAGE REQUIREMENTS	06/23/85

```
                                        1987       :    1988                          :
                               CALENDAR:O--N--D--:J--F--M--A--M--J--J--A--S:
                                 FISCAL:FY 88                               :
                                  MONTH:1  2  3   4  5  6  7  8  9 10 11 12:
                                PHASE B:                                    :
                                      C:                                    :
STUDY TASKS                             :                                    :
4. Formulate Requirements & Specs.      :---                                 :
   (Continued)                          :(4 m/m)                             :
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REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
109M02	DATA FILE STOWAGE REQUIREMENTS	06/23/85

SUMMARY SCHEDULE/COST FACTORS

STUDY SPAN: 10-86 to 11-87 CM =13

CATEGORY	FACTOR/MM(CM)*	COST $
LABOR		
- NASA Project Mgmt	3	
- Study Mgmt		
- Study Tasks		
- Analyst, Eng'g	13	
- Special Skills:		
SPECIAL FACILITIES		0
TRAVEL		
1. Trips to NASA Centers for Phase B Study Input and SSP Reviews		4 K
MATERIALS		0
TEST PROGRAM		0
OTHER (List)		0

* MM = Manmonths; CM = Calendar Months

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REPORT FORMAT 13 MANAGEMENT PLAN OVERVIEW

NUMBER	TITLE	DATE
109M03	TRASH-WASTE STOWAGE/STORAGE	06/22/85

ISSUE #	TITLE	NEED DATE
1090301	TRASH-WASTE STOWAGE/STORAGE	NOV 1986

OBJECTIVES:

(01) To determine the volume required for trash-waste stowage in various habitable areas of the Space Station.

(02) And to determine the locations of trash-waste stowage compartments in various Space Station modules.

BACKGROUND:

In Skylab, the trash management system functioned adequately. Biologically active trash (urine bags, food cans, clothes, etc.) were place in trash bags (total 366), disposal bags (168) or urine disposal bags (149) and deposited into the waste tank below the crew quarters. The waste tank itself was actually an empty S-1VB liquid oxygen tank. It was utilized as a trash storage area because it enclosed a large volume (in excess of 2800 cubic feet) and was not committed to other equipment or storage use. To prevent pressure buildup due to trash off-gassing, the tank was vented to space. A network of fine-mesh screens were installed to prevent dumped solids and liquids from migrating into space. Inert trash was deposited into plenum bags (duffel bags) prior to transfer and storage in the S-1VB waste tank (02).

The Soviets routinely package their garbage and debris and dump the package overboard through the airlock. Toilet filters, towels, food packages, and soiled clothing were stowed in trash bags, "The bags are sealed, placed in one of two side-by-side trash ejection airlocks and jettisoned..."(04). The Soviets also used their resupply ship (the Progress) as waste-trash storage tank.

The equipment available aboard the Shuttle Orbiter includes wet trash stowage containers, wet trash vent hose, a dry trash stowage compartment and a wet trash stowage compartment. The dry trash stowage compartment is located on the aft bulkhead of the mid-deck. The available storage volume is approximately 6 cubic ft. Empty food lockers are also available for dry trash storage. Additional components are Jettison Stowage Bags and In-flight Stowage Restraint Bags. Each of these bags have an available volume of approximately 4 cubic ft. The Wet Trash Storage compartment has an available volume of 8 cubic ft. and is located between the airlock and the sleep station. The compartment is continuously vented at a rate of 1 lb/day to a vacuum vent in the waste collection subsystem.

INPUTS:

A. Space Station Trash Generation Model (2130101)
B. Contamination and Odor Control Requirements (20103)
C. SSP Reference Documents (i.e. SS Reference Configuration and Preliminary Design, Trash Stowage Locations and Volume Allocations)

CRITICAL_ASSUMPTIONS:

(01) The stowage and storage of waste/trash will be a shared responsibility for all of the crew.
(02) Stowage/storage containers and restraints will be standardized.
(03) Need date for imputs A & B is the IRR.

SPECIAL_REMARKS:

(01) A previous study, Space Station Housekeeping and Trash Management Study, performed by ILC Space Systems for NASA JSC-MSD will facilitate the work done under this management plan.
(02) Coordination with Ames Research Center (work package 1 & 3) for storage/stowage of toxic chemicals and biologically active materials in the Space Station.

REFERENCES:

(01) Boeing Aerospace Co., NASW-3680/CC0081 Space Station Hab. Report 02/28/83.
(02) Space Station Housekeeping and Trash Management Study, ILC-SSD NAS9-16589.

(03) Space Station Reference Configuration JSC19989. NASA-JSC, Aug. 1984.

(04) Oberg, J. E. Red Star in Orbit. 1st edition, New York: Random House, 1981.

REPORT FORMAT 14 STUDY PLAN

NUMBER	TITLE	DATE
109M03	TRASH-WASTE STOWAGE/STORAGE	06/22/85

STUDY_TASKS:

(01) Perform a literature review to evaluate alternative methods for long term stowage of trash and waste. In the areas of trash-waste storage, problem areas will be identified such as insufficient or inconvenient stowage/storage volumes or locations. Another subtask will be to review NASA/Contractor reports on proposed Space Station trash storage provisions. This will identify preliminary volume allocations and locations within the Space Station.

(02) Perform trade study analysis to determine the volume and configuration of trash-waste stowage/storage compartments to be provided in the Space Station. Volume will be dependent on the results of the Trash Generation Model (2130101). Performance of trade studies will include the impact of a trash compactor on volume reduction vs. non-compacted trash. The output of this task will be a list of requirements defining the volume of waste-trash stowage containers.

(03) Perform trade study analysis to determine the location of trash-waste stowage/storage compartments to be provided in the Space Station. Input from the Trash Generation Model (2130101) will determine areas of high waste-trash production. Performance of trade studies will include centralized vs. localized stowage/storage locations.

(04) Formulate requirements and specifications for the location and volume of trash-waste stowage/storage compartments in the Space Station.

SPECIAL_STUDY_NEEDS:

TASK(S)	NEED
	None identified.

SPECIAL_SKILLS:

TASK(S)	SKILL

None identified.

PERFORMING ORGANIZATION:

MANAGING: NASA, JSC-MSD

DOING: Aerospace Firms (Prime)

Industrial Firms (Sub)

NASA Resources (Sub)

STUDY PRODUCTS:

(01) Baseline waste-trash stowage/storage system concepts and definition.
(02) Design specifications and requirements for waste and trash stowage/storage system.

PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS:

SUBELEMENT NO. & TITLE	Undefined Rqmt #
10903 Trash-Waste Stowage/Storage	-01, -02, -03

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
109M03	TRASH-WASTE STOWAGE/STORAGE	06/22/85

	1984			1985								
CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S
FISCAL	FY 85											
MONTH	1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												
STUDY TASKS												
1. Literature Review											C	--

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
109M03	TRASH-WASTE STOWAGE/STORAGE	06/22/85

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                                          1985       |    1986                          |
___________________________________CALENDAR|O--N--D--|J--F--M--A--M--J--J--A--S|
                                     FISCAL|FY 86                                      |
______________________________________MONTH|1  2  3   4  5  6  7  8  9 10 11 12|
                                    PHASE B|                                            |
                                          C|                                            |
STUDY  TASKS_______________________________|____________________________________|
1.  Literature Review                      |--                                          |
                                           |(1 m/m)                                     |
                                           |                                            |
2.  Trade Study Analysis                   | A ------------                             |
    and Volume Determination               | B     (3 m/m)                              |
                                           |                                            |
3.  Trade Study Analysis                   |           -------------                    |
    and Location Determination             |               (3 m/m)                      |
                                           |                                            |
4.  Formulate Requirements and             |                  ----------------|
    Specifications                         |                        (4 m/m)   |
                                           |                                            |
                                           |                                            |
                                           |                                            |
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REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
109M03	TRASH-WASTE STOWAGE/STORAGE	06/22/85

	1986			1987								
CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S
FISCAL	FY 87											
MONTH	1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												
STUDY TASKS												
4. Requirements and Specifications	---											

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
109M03	TRASH-WASTE STOWAGE/STORAGE	06/22/85

SUMMARY SCHEDULE/COST FACTORS

STUDY SPAN:	08/85 - 11/86 CM = 12	
CATEGORY	FACTOR/MM(CM)*	COST $
LABOR		
- NASA Project Mgmt	1	
- Study Mgmt		
- Study Tasks		
- Analyst, Eng'g		
- Special Skills:	11	

SPECIAL FACILITIES

TRAVEL

Travel to NASA facilities to coordinate and receive SSF program information	2K

MATERIALS

TEST PROGRAM

OTHER (List)

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* MM = Manmonths; CM = Calendar Months

NUMBER	TITLE	DATE
201M01	ATMOSPHERE SPECIFICATION	07-19-85

ISSUE #	TITLE	NEED DATE
2010101	ATMOSPHERE SPECIFICATION	DEC 85

OBJECTIVES:

(01) Determine permissable ranges of temperature, humidity, and airflow rate for crew health and comfort at all major locations within station.

(02) Define mixture range of major atmosphere constituents.

BACKGROUND:

Existing atmosphere specifications are based primarily on crew health requirements. On extended missions with non-career astronaut crewmembers, crew comfort becomes increasingly important. Experience with Skylab (Ref. 01) indicated that non-uniform cabin temperature and insufficient positive airflow at the exercise station were troublesome for the crew. On Salyut, headaches were noted by the crew when CO2 partial pressure was allowed to rise to 6-7 mm Hg (Ref. 02).

The purpose of this study is to define the specifications for the cabin atmosphere which will provide a comfortable as well as safe environment for the crew. This atmosphere specification will include atmosphere constituent limits, temperature, humidity, and airflow profiles at various activity stations.

INPUTS:

A. Existing spacecraft atmosphere specifictions including degraded and emergency conditions.
B. Manned Space Systems experience data including crew reports regarding the IVA atmosphere.
C. Human Factor psychological and physiological data on crew comfort and health requirements.
D. Proposed Space Station IVA operations data.
E. Determination of total cabin and EMU pressures for Space Station.

CRITICAL ASSUMPTIONS:

(01) Modifications to accepted current spacecraft atmosphere limits and activity levels are applicable to Space Station.

(02) Crew comfort conditions factors for non-career astronauts can be extrapolated from data obtained on previous spaceflights where the crew was composed of highly motivated, dedicated, career astronauts.

SPECIAL REMARKS:

(01) This study must be completed early in Phase B. The results are to be used during Space Station hardware definition.

(02) Space Station cabin pressure will depend on EVA and laboratory requirements. Atmosphere constituent partial pressures must be selected accordingly.

(03) Airflow rates and directions at individual activity stations must be chosen so as not to oppose overall cabin airflow and must not produce uncomfortable or unsafe conditions at any activity station.

(04) When determining special atmospheric specifications for various activity stations, consideration is to be given to the type of activity performed, to the associated physiological effects relative to comfort which an activity has on crewmembers, and the gross physiological demands which the activity produces.

(05) Contaminant limits and control will be defined in Management Plan 201M05 - CONTAMINATION LIMITS AND GASEOUS LOAD MODEL.

REFERENCES:

(01) NASA Solicitation #9-BF-10-4-01P, "Space Station Habitability Design Recommendations, Vol I" Nov 84

(02) Boeing Aerospace Company, D180-28402-1 "Soviet Space Stations as Analogs", Oct 83

REPORT FORMAT 14 STUDY PLAN

NUMBER	TITLE	DATE
201M01	ATMOSPHERE SPECIFICATION	07-19-85

STUDY TASKS:

To resolve this issue, it will be necessary to convene a board of experts familiar with conditions prevailing on extended space missions who can determine atmosphere specifications. The board will be composed of NASA and contractor representatives.

(01) Define Atmosphere Constituent's Partial Pressures - The board will consider Space Station cabin and EMU total pressures and determine allowable ranges of partial pressures for major atmospheric constituents under normal, degraded, and emergency conditions. The study shall consider selection of partial pressures so as to minimize EVA oxygen prebreath and projected crew activity. It shall also consider crew comfort as well as health requirements.

(02) Define CO_2 Partial Pressures - The board will consider existing spacecraft atmosphere specifications, previous spaceflight specifications, and human factor data to determine CO_2 partial pressure limits vs. crew activity and exposure duration for normal, degraded, and emergency conditions. The study shall consider crew comfort as well as health requirements.

(03) Define Cabin Air Flow Rates/Temperature/Humidity - The board will consider existing spacecraft atmosphere specifications, previous spaceflight and human factor data and determine ranges for overall cabin air exchange rate, maximum airflow rate allowable at any point in the cabin from the air outlets and inlets, average temperature, and average relative humidity.

(04) Identify Activity Areas Requiring Special Atmosphere Specs - The board will consider planned Space Station IVA operations data, previous spaceflight data, and human factors data and define activity stations requiring special airflow, temperature and relative humidity. The study shall consider activity areas where crew metabolic activity is likely to require additional airflow, areas where crew may be inconvenienced by drafts, areas where work is done which would require additional ventilation, and any locations requiring special temperatures or relative humidities to enhance crew comfort.

(05) Identify Activity Area Special Atmosphere Specification - The board will consider human factor data and IVA operations data and determine the range of airflow rate vs temperature and humidity which will be allowed at each station identified in Task 4. The study will consider conditions which will enhance crew comfort and efficiency, including restrictions on possible interference with other work stations.

(06) Prepare Atmosphere Specification - Write a clear, comprehensive, and descriptive atmosphere specification to be used as a guideline for engineering design. Specification will include results from resolution of Study Tasks 1 - 5 above.

SPECIAL STUDY NEEDS:

TASK(S)	NEED
	None

SPECIAL SKILLS:

TASK(S)	SKILL
1,2,3,4,5,6	A physiologist and a psychologist familiar with crew comfort experience gained from previous long-term space missions.
1,2	A physiologist who can define acceptable atmosphere constituent partial pressures.
4,5	A human factors specialist familiar with proposed Space Station crew tasks.

PERFORMING ORGANIZATION:

(01) Managing: NASA/JSC Manned Systems Division

(02) Doing: Expert panel composed of contractor, NASA, and academia experts

STUDY PRODUCTS:

Atmosphere specifications document containing:

(01) Definition of cabin atmosphere basic composition and constituent partial pressures.

(02) CO2 partial pressure limits.

(03) Cabin air temperature, relative humidity, and exchange rate ranges.

(04) Cabin airflow rate vs. temperature and relative humidity at selected locations.

PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS:

SUBELEMENT NO. & TITLE	Undefined Rqmt #
20101 ATMOSPHERE REVITALIZATION	-02a, -02b

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
201M01	ATMOSPHERE SPECIFICATION	07-19-85

	1985			1986								
CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S
FISCAL	FY 86											
MONTH	1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												
STUDY TASKS	A C E											
1. Define Atmosphere Constituent's Partial Pressures	--- (1 mm)											
2. Define CO2 Partial Pressures	--- (1 mm) B											
3. Define Cabin Air Flow Rates/Temps/ Humidity	--- (1 mm) D											
4. Identify Activity Areas Requiring Special Atmosphere Specs	--- (1 mm)											
5. Identify Activity Area Special Atmosphere Specs	--- (1 mm)											
6. Prepare Atmosphere Specification		--- (1 mm)										

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
201M01	ATMOSPHERE SPECIFICATION	07-19-85

SUMMARY SCHEDULE/COST FACTORS

	STUDY SPAN: Oct 85-Dec 85 CM = 2	
CATEGORY	FACTOR/MM(CM)*	COST $
LABOR		
- NASA Project Mgmt	1 mm	
- Study Mgmt	2 mm	
- Study Tasks		
- Analyst, Eng'g	1 mm	
- Special Skills:		
-Physiologist (Space Mission)	1 mm	
-Psychologist (Space Mission)	1 mm	
-Psychologist (Civilian Crew)	1 mm	
-Physiologist (Atmosphere Reqmnt)	1 mm	
-Human Factors Specialits	1 mm	
SPECIAL FACILITIES		
TRAVEL		
- Board of experts travel to JSC		15 K
MATERIALS		
TEST PROGRAM		
OTHER (List)		

* MM = Manmonths; CM = Calendar Months

NUMBER	TITLE	DATE
201M03	MAINTAIN/TEST POTABLE WATER PURITY	6-21-85

ISSUE #	TITLE	NEED DATE
2010202	MAINTAIN/TEST POTABLE WATER PURITY	N/A

OBJECTIVES:

(01) Specify water contaminant levels.

(02) Specify analytical instruments and methods.

(03) Specify methods for maintaining water purity in the Space Station.

BACKGROUND:

The requirement for a partially-closed Space Station ECLSS implies regeneration of waste water to a level of purity which will be both safe and palatable for crew consumption. Current NASA potable water specifications (SD-W-002) levies maximum contaminant level and characteristics for: electrical conductivity, pH, total solids, total organic carbon, taste and odor, turbidity, color, specific ionic species, and sterility.

To assure that a sufficient amount of potable water is supplied to crew interfaces, specified waste water sources must be regenerated to a level meeting a defined purity. To accomplish this, a group of water processing components must be provided to accomplish water collection, treatment, controlling, and monitoring. The work required in Section 3.1.2.4 of the NASA RFP 9BE2-2-5-60P "Technology Demonstrator for a Regenerative Environmental Control Life Support System" requires the definition of the potable water system requirements and will, therefore, resolve Issue 2010202.

INPUTS:

A. NONE

CRITICAL ASSUMPTIONS:

(01) The work encompassed in the NASA RFP 9BE2-2-5-60P "Technology Demonstrator for a Regenerative Environmental Control Life Support System" will satisfy the requirements of Issue Number 2010202.

SPECIAL REMARKS:

(01) NASA should convene an ad-hoc committee of experts from NASA, Aerospace contractors and the scientific community to review existing water quality standards and establish an updated potable water specification.

REFERENCES:

(01)

REPORT FORMAT 13 MANAGEMENT PLAN OVERVIEW

NUMBER	TITLE	DATE
201M04	WATER ALLOCATION FOR CREW SUPPORT	07-17-85

ISSUE #	TITLE	NEED DATE
2010203	WATER ALLOCATION FOR CREW SUPPORT	APR 86

OBJECTIVES:

(01) Define integrated crew support water requirements.

BACKGROUND:

The Space Station will require substantial quantities of water allocated to crew support functions.

Previous spaceflight missions have used disposable clothes and food serving vessels. However, for multiple, prolonged missions aboard the Space Station, reuse of clothing and food serving vessels becomes essential. Clothes and dish washing devices have not been flight tested but will be developed for the Space Station.

For crew hygiene, showers and hand washers will be developed. The waste management system will also be a substantial water consuming crew support function.

Requirements for these various water consuming crew support appliances are defined under separate studies. The purpose of this study is to integrate the water consumption data from these other studies into a comprehensive hygiene and wash water requirements definition for crew support.

INPUTS:

A. Water requirements for a clothes washer to be resolved under Issue 2120501.
B. Water requirements for a dishwasher to be resolved under Issue 2120601.
C. Water requirements for whole-body shower to be resolved under Issue 2100202.
D. Water requirements for partial-body cleaning to be resolved under Issue 2100301.
E. Water requirements for body waster management to be resolved under Issues 2100101 AND 2100102.

CRITICAL ASSUMPTIONS:

(01) Issues 2120501, 2120601, 2100201, 2100202, 2100301, 2100101 and 2100102 will be resolved by on-going or future contractural studies.

(02) The issues listed in (01) represent all hygiene and wash water requirements.

SPECIAL REMARKS:

(01) Technical portion of study is encompassed by Issues 2120501, 2120601, 2100201, 2100202, 2100301, 2100101 and 2100102.

REFERENCES:

(01) Space Station Human Productivity Requirements, (NASA document TBD), NASA-JSC, (Release date TBD) (See requirements for subelements 21001, 21002, 21003, 21205, 21206)

REPORT FORMAT 14 STUDY PLAN

NUMBER	TITLE	DATE
201M04	WATER ALLOCATION FOR CREW SUPPORT	07-17-85

STUDY TASKS:

(01) Define Crew Support Water Allocation Requirements - Collect and integrate water allocation (quality/quantity) requirements determined under Issue studies 2120501, 2120601, 2100202, 2100301, 2100101, 2100102.

SPECIAL STUDY NEEDS:

TASK(S)	NEED
	None

SPECIAL SKILLS:

TASK(S)	SKILL
	None

PERFORMING ORGANIZATION:

(01) Managing: NASA-MSFC (WP01)

(02) Doing: WP01 Contractor

STUDY PRODUCTS:

Water allocation requirements for all identified hygiene and wash support subsystems.

PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS:

SUBELEMENT NO. & TITLE	Undefined Rqmt #
20102 WATER MANAGEMENT	-02c

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
201M04	WATER ALLOCATION FOR CREW SUPPORT	07-17-85

	1985			1986								
CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S
FISCAL	FY 86											
MONTH	1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												
STUDY TASKS												
1. Water Allocation Documentation				----------- (4 mm)								

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
201M04	WATER ALLOCATION FOR CREW SUPPORT	07-17-85

SUMMARY SCHEDULE/COST FACTORS

STUDY SPAN:	Jan 86-Apr 86 CM = 4	
CATEGORY	FACTOR/MM(CM)*	COST $
LABOR		
- NASA Project Mgmt		
- Study Mgmt		
- Study Tasks		
- Analyst, Eng'g	4 mm	
- Special Skills:		
SPECIAL FACILITIES		
TRAVEL		
MATERIALS		
TEST PROGRAM		
OTHER (List)		

* MM = Manmonths; CM = Calendar Months

REPORT FORMAT 13 MANAGEMENT PLAN OVERVIEW

NUMBER	TITLE	DATE
201M05	CONTAMINATION/ODOR CONTROL	06-26-85

ISSUE #	TITLE	NEED DATE
2010301	GASEOUS CONTAMINANT LOAD MODEL	Jul 87
2010302	MICROBIAL LOAD MODEL	Jul 87

OBJECTIVES:

(01) Develop an internal gaseous contaminant load model for the space station including considerations of spacecraft materials, equipment, experiments and man.

(02) Develop a microbial load model for the space station considering sources of bacterial contamination, type of bacteria to be encountered, and the degree of proliferation.

(03) Provide preliminary models for preliminary design of the Space Station and then update the models for final design during Phase C/D of the Space Station contract effort.

BACKGROUND:

Internal gaseous contaminant control has been of concern for every manned spacecraft. Early vehicles relied on a minimal amount of materials testing and all-up verification during the final phases of assembly and test of the flight vehicle. The long duration mission associated with Space Station places greater emphasis on contamination control. The most extensive contaminant control survey conducted to date was accomplished for the Spacelab flights of Shuttle. Preliminary load models were prepared during the design phase based on previous materials and "black box" tests. Preflight load models were prepared based on actual test data taken from equipment and experiment offgassing tests. Both preliminary and final models were used to verify adequacy of the gaseous contaminant control system. These previous models plus grab sample data from Spacelab will support the preparation of a preliminary model for the Space Station. Although far more limited, similar data on biological contamination can also be used to define a microbial model.

Preparation of both of these models is currently being addressed by Lockheed under contract NAS 8-36406 to NASA-MSFC. This effort consists of collecting and reviewing data from previous flights and ground tests, analysis of the available data, postulation of unique space station requirements, and compilation of Space Station load models.

INPUTS:

A. Apollo, Skylab and Space Shuttle/Spacelab contaminant monitoring data.

B. Weight of Space Station Equipment in Pressurized Modules
C. Data on special gaseous compounds used in Space Station experiments.
D. Data on crew accommodations, food waste handling, waste collection and processing and personal hygiene facilities and equipment.
E. Space Station environment definition, i.e., air flows, humidity.

CRITICAL ASSUMPTIONS:

(01) Space Station equipment will produce gaseous contamination very similar to that produced during previous manned spaceflights.

(02) Microbial environments found in previous manned systems are a good basis for initial predictions for Space Station.

(03) A materials, process and operation control plan will be part of the Space Station development program.

SPECIAL REMARKS:

(01) All previous models have produced one or more contaminants that were either non-allowed or drove the design to a prohibitive degree, thereby resulting in rather tight materials screening.

(02) The desire to avoid venting of materials overboard will make the contaminant control problem more severe by eliminating the chance of using a vacuum desorbed charcoal bed.

REFERENCES:

(01) NASA, Space Station Trace Contamination Control, Contract NAS8-36406, MSFC, Huntsville, AL

(02) Lockheed Missiles & Space Co. Inc., Development of a Computer Program for Spacelab Contaminant Control Analysis, LMSC D556710, Sunnyvale, CA

REPORT FORMAT 13 MANAGEMENT PLAN OVERVIEW

NUMBER	TITLE	DATE
201M06	CONTAMINATION LIMITS	06-17-85

ISSUE #	TITLE	NEED DATE
2010303	CONTAMINATION DOSE LIMITS	Prel. 6/86 Final 7/87

OBJECTIVES:

(01) Provide Spacecraft Maximum Allowable Concentrations (SMAC) for all gaseous contaminants identified in the Space Station contaminant load model for which current SMACs have not been established.

(02) Modify existing 7, 10 and 30 day SMAC data to support the 90 day Space Station crew rotation schedule.

(03) Provide allowable aerosol levels for the Space Station cabin atmosphere for those aerosols listed in the Space Station Contaminant Study Guide.

(04) Provide a microbial contamination plan with emphasis on types of bacteria and limit criteria.

BACKGROUND:

An important element in the analysis and design of the Space Station contaminant control and monitoring system is the definition of allowable levels of gaseous, particulate, aerosol and bacterial contamination. No contamination is a desirable, but unfortunately unachievable goal, so realistic levels must be set that balance crew safety with control complexity and achievability. Allowable particulate levels are most easily established based on particle size and total count and can be most readily controlled to reasonable values. Gaseous contaminant levels have received the most attention and SMACs have been established for many chemical compounds. The gaseous contaminant lists have grown, however, as the spacecraft has become more complex and the chemical analysis capability has advanced, so that, new compounds for which SMACs are needed have been added to the contaminant load model. Also, many SMAC values are limited to 7, 10 and 30 day exposure times. Less attention has been paid to aerosols, but they are also amenable to standard toxicological analysis and comparison to similar species for which data is known. Establishment of a aerosol load model for Space Station is an important first step in the process of setting limits. Microbiological limits have received the least attention and may be handled in real time as samples are taken and data is collected.

The present issue resolution management plan provides a technical approach to setting limits for all contaminants through comparisons with similar situations, extrapolation of previous data, new studies and tests, and coordination with Space Station systems definition and load model development efforts.

INPUTS:

A. Data from Skylab, Spacelab, Space Shuttle on previous contaminant types, environments, and contaminant levels.
B. Space Station predictions of contaminant types and levels.
C. Industrial standards (TLV)
D. Submarine Habitability Handbook data on allowable levels.
E. Animal and human toxicological test data.

CRITICAL ASSUMPTIONS:

(01) Allowable contaminant levels can be established for spacecraft use based on industrial standards ratios.

(02) Homolog analogies provide a valid approximation of allowable levels.

(03) Synergistic effects of multiple contaminants can be controlled by a class summary equation.

SPECIAL REMARKS:

(01) It is very desirable to establish standards based on existing industrial and space experience and existing animal and human toxicological test data in order to avoid time consuming and costly testing.

(02) The conservative approach to setting allowable concentrations to date has provided workable safe levels and can probably be followed successfully for the Space Station without undue penalty.

(03) The approach to setting of microbiological standards and levels poses the most difficult task because the sources, production rates, and measurement techniques are less well defined.

REFERENCES:

(01) Flammability Odor and Offgassing Requirements and Test Procedures for Materials in Environments that Support Combustion, NHB 8060.1

(02) NASA-JSC, STS Microbial Contamination Control Plan, JSC-16888, Houston, TX

REPORT FORMAT 14 STUDY PLAN

NUMBER	TITLE	DATE
201M06	CONTAMINATION LIMITS	06-17-85

STUDY TASKS:

(01) Obtain Space Station Contaminant Load Model Data from NASA and/or study contractor.

(02) Prepare limit status list of contaminants and identify those for which 7, 10 and 30 day limits exist, TLV's exist, or animal or human research data exists.

(03) For those contaminants that have no direct data on allowable levels, establish whether homolog analogies can reasonably be used to predict allowable levels.

(04) Identify those contaminants on the model list that are either very toxic or have high production rates.

(05) Prepare a master list of those contaminants from tasks (03) and (04) that require more exhaustive research or testing to provide the required confidence level, because they are design drivers.

(06) Perform contaminant removal predictions studies to verify which contaminants are the most critical ones.

(07) Plan the animal and human research required to provide the needed toxicological data.

(08) Conduct the research testing and analyze the data.

(09) Prepare the complete allowable concentration data list.

SPECIAL STUDY NEEDS:

TASK(S)	NEED
1	Awareness of current and previous studies, contractors and NASA agency roles.
2	Access to existing records for current limits & data
6	Computerized analysis tools
7, 8	Toxicological test facilities and procedures

SPECIAL SKILLS:

TASK(S)	SKILL
1,2,3,9	Spacecraft Physician (Toxicology)

1,2,3,4,5,7,8,9	Toxicologist
1,2,3,4,5,6,7,8 & 9	Microbiologist
1,4,6	Contaminant Control Engineer
7,8	Test Subjects and Test Personnel
3	Chemist

PERFORMING ORGANIZATION:

(01) Managing: NASA Laboratories

(02) Doing: NASA Laboratories (Prime)
Aerospace Firms (Sub)
Test Laboratories (Sub)

STUDY PRODUCTS:

Detailed design specifications for:

(01) Maximum allowable contaminant levels for gaseous, microbiological, particulate and aerosol contaminants.

(02) Methods for establishing synergistic effects and limits.

(03) Recommendations for control and monitoring of environment.

PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS:

SUBELEMENT NO. & TITLE	Undefined Rqmt #
20103 CONTAMINATION/ODOR CONTROL	-02,-06,-12

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
201M06	CONTAMINATION LIMITS	06-17-85

	1984			1985								
CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S
FISCAL	FY 85											
MONTH	1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												
STUDY TASKS												
1. Contaminant Load Model Data											A	---
											B	1mm

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
201M06	CONTAMINATION LIMITS	06-17-85

	1985			1986								
CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S
FISCAL MONTH	FY 86 1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												

STUDY TASKS		PREL.	UPDATE
2. Contaminant Limits Status List	C D E	2mm	.5mm
3. Homolog Analyses		2mm	.5mm
4. Identification of Very Toxic Contaminants		1mm	.25mm
5. Design Drivers Identification		1mm	.25mm
6. Contaminant Removal Predictions		3 mm	.5mm
7. Research Plan		4mm	1mm
8. Research Testing			21mm
9. Allowable Limits List			Prel 1mm

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
201M06	CONTAMINATION LIMITS	06-17-85

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                                    1986       ¦     1987                             ¦
                            CALENDAR¦O--N--D--¦J--F--M--A--M--J--J--A--S--¦
                              FISCAL¦FY 87                                 ¦
                               MONTH¦1  2  3   4  5  6  7  8  9  10 11 12 ¦
                             PHASE B¦                                      ¦
                                   C¦                                      ¦
STUDY  TASKS                        ¦                                      ¦
                                    ¦                                      ¦
8. (cont)                           ¦----------                            ¦
                                    ¦   9mm                                ¦
                                    ¦         Final                        ¦
9. (cont)                           ¦         ----                         ¦
                                    ¦         3 mm                         ¦
```

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
201M06	CONTAMINATION LIMITS	06-17-85

SUMMARY SCHEDULE/COST FACTORS

STUDY SPAN: Sep 85-Feb 87 CM = 18

CATEGORY	FACTOR/MM(CM)*	COST $
LABOR		
- NASA Project Mgmt		
- Study Mgmt	8 MM	
- Study Tasks		
- Analyst, Eng'g	4 MM	
- Special Skills:		
Spacecraft Physician	3 MM	
Toxicologist	8 MM	
Microbiologist	8 MM	
Chemist	2 MM	
Test Personnel	18 MM	
SPECIAL FACILITIES		
Toxicological Test Facility including Animal Colony		existing
TRAVEL		
Coordination w/NASA & Aerospace Companies		15 K
MATERIALS		
Test chemicals and expendables		10 K
TEST PROGRAM		
Test subject for toxicological testing		50 K
OTHER (List)		

* MM = Manmonths; CM = Calendar Months

NUMBER	TITLE	DATE
202M01	RADIATION MONITORING SYSTEM REQUIREMENTS	07-17-85

ISSUE #	TITLE	NEED DATE
2020101	RADIATION MONITORING SYSTEM	APR 88
2020102	PERSONNEL DOSIMETRY	MAR 86

OBJECTIVES:

(01) Develop performance requirements for Space Radiation Monitoring System.

(02) Identify spacecraft hardware and software interfaces of Radiation Monitoring System.

BACKGROUND:

Human performance in space will be affected by uncertainity regarding the radiation dose rates and accumulated doses over the course of the mission. Further, federal law requires that when workers are exposed to radiation, their working environment and the individual personnel doses be monitored.

The ionizing radiation of space has several components:

o High-energy protons and electrons that are trapped by the earth's magnetic fields into "belts" or equatorial regions around the earth.

o High-energy protons and other nuclei that originate from solar flare events on the sun.

o High-energy galactic cosmic rays consisting of protons and high-z particles which are fully (or nearly so) stripped nuclei of iron, silicon, and other atoms.

In space, in the projected (and assumed) orbits of Space Station, relatively small dose rates and accumulating personnel dose rates are expected from the geomagnetically trapped protons and electrons (Ref. 2). Protons associated with solar flare events may pose a serious occasional threat. Galactic HZE particles will also be present.

The purpose of this study is to define the means for continuously monitoring and recording ionizing radiation levels within the spacecraft (and perhaps outside in the free field also) and the accummulated radiation dosages received by each crew member. The functional and performance requirements for such a system must be determined before the spacecraft design is final and interfaces defined (Ref. 1). The system itself can then be designed, built and installed integrally with spacecraft manufacture.

INPUTS:

A. Common module preliminary design data
B. Laboratory and habitat configurations
C. External Space Station configuration
D. Management Plane 202M02 - SHIELDING CONFIGURATION
E. Electrical cable layout

CRITICAL ASSUMPTIONS:

(01) The orbits for which the Space Station missions are planned have altitudes less than 500 km and inclinations less than 28.5 deg.

(02) Crewmembers will be monitored during their continuous occupancy of up to one year inside Space Station (IVA). In addition, they will also be monitored during any EVA activity they might undertake. The EVA monitoring requirements are expected to be covered in another study and its results integrated with those for IVA monitoring. In this way the design specifications for radiation monitoring equipment will comprehensively cover both IVA and EVA needs.

(03) Milestone Dates: RUR2 - Oct 85; IRR - Jan 86; SRR - Apr 86; ISR Jun 86; SDR - Jan 87; PDR - Jan 88.

SPECIAL REMARKS:

(01) Federal regulations on radiation exposures to terrestrial workers are firmly established. Until recently, the NASA radiation standards for workers in space were the recommendations of the Radiological Advisory Panel (RAP) of the Committee on Space Medicine of the National Academy of Sciences in 1970 (Ref. 1). For Space Station, NASA has established newer radiation exposure limits which are lower than those of the RAP. Based on the 15 years of intervening experience, these standards may be further changed in the future and the radiation monitoring system requirements ought to be flexible enough to accommodate such changes (Ref. 3).

(02) The interrelationship between the overall radiation monitoring system requirements and those specifically dedicated to dealing with HZE particles will be addressed separately in Management Plan 202M04 - HZE PARTICLE PROTECTION.

REFERENCES:

(01) J. Wefel, "Instrumentatin for Radiation Measurements in Space", Workshop on the Radiation Environment of the Satellite Power System, SPSO, CONF-7809164, U.S. DOE, Dec 1979.

(02) E. Benton and R. Henke, "Radiation Exposures During Space Flight and Their Measurement", Life Sciences and Space Research, XX(1), Vol. 3, #8, p. 171, 1983.

(03) W.K. Sinclair, "Radiation Safety Standards: Space Hazards vs. Terrestrial Hazards", Life Sciences and Space Research, XX(1), Vol. 1, 3, #8, p.151, 1983

REPORT FORMAT 14 STUDY PLAN

NUMBER	TITLE	DATE
202M01	RADIATION MONITORING SYSTEM REQUIREMENTS	07-17-85

STUDY TASKS:

(01) Exterior Radiation Environment - Using appropriate space radiation models and computer codes, determine the exterior radiation environments in the projected orbits contributed by the following sources: a) trapped radiation particles, b) solar protons emitted by solar flares and c) galactic cosmic rays including the HZE particles.

(02) Interior Radiation Fluxes and Dose Rates - Using appropriate charged particle radiation transport computer codes and results of Task 01, determine the fluxes and dose rates within the Space Station that are contributed by the following: a) trapped protons, b) trapped electrons, c) bremsstrahlung from trapped electrons, d) solar protons and e) HZE particles.

(03) Active Radiation Sensor Location - Perform a survey of available active radiation sensors based on the expected radiation fields defined in Tasks 01 and 02. Evaluate these using appropriate selection criteria (e.g., dose rate range, discrimination of different radiation fields) in order to define the type, location and number of active sensors, including: a) which sensor technologies to use, b) the need for exterior mounting, c) the location of interior sensors and d) number of spares.

(04) Active Sensor Electronic Requirements - Based on the selected active detectors from Task 3, determine the electronic system requirements for active sensors, including: a) input/output, b) radio frequency interference and noise rejection, c) accuracy and calibration, d) maintenance and reliability, e) power needs and f) user friendliness.

(05) Passive Personnel Dosimeters - Perform a survey of available passive personnel dosimeters based on the expected radiation fields defined in Tasks 01 and 02. Evaluate these using appropriate selection criteria, (e.g., range of radiation dose, readout capability) in order to define the type(s) of passive personnel dosimeters including: a) which sensor technologies to use, b) size and weight, c) accuracy, reliability and convenience, d) read out, reset and calibration.

(06) Data Requirements for Radiation Data - Based on the type, number and output characteristics of the selected radiation monitor types (Tasks 03 and 05), determine the data requirements for radiation flux, dose and dose rate data including: a) data entry, storage and retrieval and b) data manipulation and display.

(07) Computer Requirements for Radiation Monitoring System - Based on the results of Tasks 04, 05 and 06, determine computer hardware and software requirements to support the radiation monitoring system.

(08) Allocation of Computer Requirements - Prioritize the uses of the radiation monitoring output data and perform study to allocate computer requirements between ground and space and determine the level of computer dedication and priority.

(09) Hardware Interfaces with Structure - Based on the results of Tasks 03, 04 and 05, determine hardware interfaces with the Space Station structure including: weight and volume, power supply, and structural attachments.

(10) Software Interface - Based on the results of Tasks 06 and 07, determine the software interfaces with both the spacecraft and on-ground computers.

(11) Design Constraints - Determine design constraints on the radiation monitoring system and update as design evolves due to change of hardware or software interfaces.

(12) Documentation - Document the design requirements and specifications for the radiation monitoring system.

SPECIAL STUDY NEEDS:

TASK(S)	NEED
2,3,9	Availability of Space Station configuration data.
3	Access to full-scale mockups.
2	Availability of an operable three-dimensional space radiation transport code.
7,8,10,11	Availability of scoping criteria for Space Station computer requirements.
3,4,8,11	Access to space instrumentation data base which has been developed for use on satellites.

SPECIAL SKILLS:

TASK(S)	SKILL
1,2	Space radiation transport analysis.
3,4,5,6,9,11	Radiation instrumentation design.
6,7,8,9,10,11	Computer system design.

PERFORMING ORGANIZATION:

(01) Managing: NASA Laboratories (Goddard, Langley or Johnson)

(02) Doing: Aerospace Contractor (Prime)
- National Laboratories, e.g. Los Alamos National Lab (Sub)
- University Physics/Astronomy Departments, e.g. Univ of Chicago or Johns Hopkins University (Sub)

STUDY PRODUCTS:

Detailed design specifications for:

(01) Space radiation monitoring system for the Space Station.

(02) Hardware and software interfaces between the radiation monitoring system and other systems of the Space Station.

PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS:

SUBELEMENT NO. & TITLE		Undefined Rqmt #
20201	RADIATION PARTICLES	-01, -02
20202	TRAPPED PROTONS	-01
20203	TRAPPED ELECTONRS	-01

REPORT FORMAT 15   SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
202M01	RADIATION MONITORING SYSTEM REQUIREMENTS	07-17-85

```
                                             1985     ¦   1986                 ¦
                                     CALENDAR¦O--N--D--¦J--F--M--A--M--J--J--A--S--¦
                                       FISCAL¦FY 86                                ¦
                                        MONTH¦1  2  3   4  5  6  7  8  9  10 11 12 ¦
                                      PHASE B¦                                     ¦
                                            C¦                                     ¦
STUDY  TASKS                                 ¦                                     ¦
Assuming:  Oct 85 for RUR-2                  ¦                                     ¦
           Jan 86 for IRR                    ¦                                     ¦
           Apr 86 for SRR                    ¦                                     ¦
           Jun 86 for ISR                    ¦                                     ¦
1. Exterior Radiation Environment            ¦---                                  ¦
                                             ¦(1 mm)                               ¦
2. Interior Radiation Fluxes and             ¦-------------------------------------¦
   Dose Rates                                ¦              (2 mm)                 ¦
3. Active Sensor Location                    ¦   ----------------------------------¦
                                             ¦              (1 mm)                 ¦
4. Active Sensor Electronic Reqmts.          ¦   ----------------------------------¦
                                             ¦              (1 mm)                 ¦
5. Passive Personnel Dosimeters              ¦         -------                     ¦
                                             ¦         (2 mm)                      ¦
6. Data Rqmts for Radiation Data             ¦----------------------------         ¦
                                             ¦             (2 mm)                  ¦
7. Computer Reqmts for Radiation             ¦   -------------------------         ¦
   Monitoring System                         ¦             (2 mm)                  ¦
8. Allocation of Computer Reqmts             ¦   -------------------------         ¦
                                             ¦             (1.5 mm)                ¦
9. Hardware Interfaces with Structure        ¦   ----------------------------------¦
                                             ¦             (3 mm)                  ¦
10. Software Interfaces                      ¦   ----------------------------------¦
                                             ¦             (3 mm)                  ¦
11. Design Constraints                       ¦   ----------------------------------¦
                                             ¦             (4 mm)                  ¦
12. Documentation                            ¦   ----------------------------------¦
                                             ¦             (2.5 mm)                ¦
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REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
202M01	RADIATION MONITORING SYSTEM REQUIREMENTS	07-17-85

	1986			1987								
CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S
FISCAL	FY 87											
MONTH	1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												
STUDY TASKS												
Assuming: Jan 87 for SDR												
2. (cont)	-- (1.5 mm)											
3. (cont)	-- (1 mm)											
4. (cont)	-- (1 mm)											
9. (cont)	------ (1 mm)											
10. (cont)	------ (1 mm)											
11. (cont)	-- (2 mm)											
12. (cont)	-- (.5 mm)											

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
202M01	RADIATION MONITORING SYSTEM REQUIREMENTS	07-17-85

```
                                     1987        |    1988                                 |
                            CALENDAR|O--N--D--|J--F--M--A--M--J--J--A--S--|
                              FISCAL|FY 88                                              |
                               MONTH|1   2   3    4   5   6   7   8   9   10  11  12 |
                             PHASE B|                                                   |
                                   C|                                                   |
STUDY  TASKS                        |                                                   |
Assuming:  Jan 88 for PDR           |                                                   |
                                    |                                                   |
2. (cont)                           |-------------------------                          |
                                    |       (.5 mm)                                     |
3. (cont)                           |-------------------------                          |
                                    |       (.5 mm)                                     |
4. (cont)                           |-------------------------                          |
                                    |       (.5 mm)                                     |
                                    |                                                   |
11. (cont)                          |------------------------                           |
                                    |       (1 mm)                                      |
12. (cont)                          |--------------------------------                   |
                                    |          (.5 mm)                                  |
```

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
202M01	RADIATION MONITORING SYSTEM REQUIREMENTS	07-17-85

SUMMARY SCHEDULE/COST FACTORS

STUDY SPAN: OCT 85-JUL 88 CM =31

CATEGORY	FACTOR/MM(CM)*	COST $
LABOR		
- NASA Project Mgmt	31.0 mm	
- Study Mgmt	31.0 mm	
- Study Tasks		
- Analyst, Eng'g	2.0 mm	
- Radiation Transport	6.0 mm	
- Rad. Instr. Design	16.0 mm	
- Computer Sys. Design	12.0 mm	
SPECIAL FACILITIES		
TRAVEL		
Coordination w/NASA, Aerospace Co's.		
Radiation Instrumentation Co's		
MATERIALS		
TEST PROGRAM		
OTHER (List)		
Computer Time		4K

* MM = Manmonths; CM = Calendar Months

REPORT FORMAT 13 MANAGEMENT PLAN OVERVIEW

NUMBER	TITLE	DATE
202M02	OPTIMAL RADIATION/MICROMETEORITE SHIELDING	07-16-85

ISSUE #	TITLE	NEED DATE
2020103	OPTIMAL SHIELDING DISTRIBUTION	APR 88
2020104	WINDOW RADIATION PROTECTION	JAN 87
2020105	SHIELDED STORAGE	OCT 87
2020801	MICROMETEORITE/DEBRIS PROTECTION	APR 86
2021001	RADIATION SHIELDING STRATEGY FOR GROWTH	APR 88

OBJECTIVES:

(01) Develop requirements for the optimal (minimum mass and volume) distribution of radiation shielding to satisfy crew exposure limitations.

(02) Develop requirements for optimal micrometeorite/debris shielding material thickness (minimum mass, volume and bremmstrahlung dose) to satisfy risk limitations; integrate micrometeorite and radiation shielding requirements.

(03) Develop requirements for window radiation attenuation.

(04) Develop requirements for shielded materials storage.

(05) Develop requirements for initial shielding design to allow for anticipated SS vehicle and mission growth.

BACKGROUND:

Since mass is always a premium commodity in spacecraft, and radiation shielding requires mass (Ref. 1) it is important to optimize the shielding design. Further, since micrometeorite and debris shields pose different design constraints from radiation shields, it is important to integrate these two protection systems (Ref. 2).

There are operational (mission) tradeoffs involved in deciding how shielding mass should be distributed (Ref. 3). At one extreme, all the mass could be placed on the spacecraft exterior walls; at the other, the crew could wear body shielding (see Fig. 1). An optimum design will take into account the amount of time spent by crew in different locations - work, recreation, sleeping - and the radio sensitivities of various body organs that may need extra shielding. Such an optimal shielding design can result only after performing the study tasks described below which will provide the data upon which design decisions can be made. Windows near work stations or recreation areas may need special attention as will storage volumes for radio sensitive materials such as photographic film (Ref. 4). Missions involving orbits beyond the current planned altitudes and inclinations will produce higher radiation levels, therefore the planning of shielding changes for anticipated growth should also be done early in the design.

INPUTS:

A. Preliminary SS design data
B. Preliminary laboratories and habitat interior configurations
C. Preliminary crew daily schedule plans
D. Radiation and micrometeorite environment data
E. Management Plan 109M01 - EQUIPMENT AND FOOD STORAGE
F. Management Plan 202M01 - RADIATION MONITORING SYSTEM

CRITICAL ASSUMPTIONS:

(01) Orbital parameters are 500 km altitude and less than 28.5 deg. inclination.

(02) A set of radiation exposure design limits will be developed which will serve as the criteria for many of the study tasks. These design limits will be derived directly from the NASA Space Station ionizing radiation exposure limits.

(03) Milestone dates: RUR2 - Oct 85; IRR - Jan 86; SRR - Apr 86; ISR - Jul 86; SDR - Jan 87; PDR - Apr 88.

SPECIAL REMARKS:

(01) Results of this study which drive shielding design should be integrated with results of Management Plan 202M03, which examines special case solar flare protection shielding drivers.

(02) Bremmstrahlung; the production of radiation particles as the result of hitting the shields.

REFERENCES:

(01) E. Beever and D. Rusling,"The Importance of Space Radiation Shielding Weight", NASA SP-71, Second Symposium on Protection Against Radiations in Space, p.407, 1965

(02) D. Brooks,"A Comparison of Spacecraft Penetration Hazards due to Meteoroids and Manmade Earth-Orbiting Objects", NASA-TM-X-73978, Nov 1976

(03) F. Bouquet,"A Space Radiation Protection System for Near-Earth Manned Orbital Space Stations", NASA PS-71, Second Symposium on Protection Against Radiations in Space, p.397, 1965

(04) J. Braly and T. Heaton,"Radiation Problems Associated with Skylab", NASA-TM-X-2440, Proceedings of the National Symposium on Natural and Man-made Radiation, Jan 1972

REPORT FORMAT 14 STUDY PLAN

NUMBER	TITLE	DATE
202M02	OPTIMAL RADIATION/MICROMETEORITE SHIELDING	07-16-85

STUDY TASKS:

(01) Exterior Radiation Environment - Using appropriate space radiation models and computer codes, determine the expected exterior radiation environments in the projected orbits contributed by the following sources: a) trapped protons and electrons, b) solar flare event protons, c) galactic cosmic rays, including HZE particles.

(02) Micrometeorite Distribution - Using the current space environment models, determine the micrometeorite and debris flux-size distribution for the projected orbits

(03) Micrometeorite Shield Materials - Based on the recent experience in designing shields against micrometeorite/debris fluxes and using the results from Task 02, determine candidate micrometeorite/debris shield materials and thickness requirements for each. (Focus on low atomic number materials).

(04) Bremmstrahlung Dose from Micrometeorite Shields - Using appropriate charged particle radiation transport computer codes and the results of Tasks 01 and 03, determine maximum bremmstrahlung dose rate for each of the candidate micrometeorite/debris shield materials and the thickness required for each.

(05) Proton Attenuation Through Micrometeorite Shields -Using appropriate charged particle radiation transport computer codes and the results of Tasks 01 and 03, determine the proton flux attenuation in each candidate micrometeorite/debris shield material, considering the buildup of secondaries.

(06) HZE Particle Attenuation Through Micrometeorite Shields - Using appropriate charged particle radiation transport computer codes and the results of Tasks 01 and 03, determine the HZE particle flux attenuation and secondary flux buildup due to the candidate micrometeorite/debris shield materials.

(07) Structural Shielding Configuration - Based on the structural design of the spaceraft and its habitat interior, determine the structural (inherent) shielding configuration that exists over and above that due to the outer skin (micrometeorite shield).

(08) Parametric Doses Through Shields and Windows - Perform a parametric shielding study of the radiation doses per day to unshielded crew organs (gut, gonads, bone marrow, skin, eye, etc.) at different crew locations (work, recreation, sleep) due to each radiation component that penetrates each candidate micrometeorite/debris shield material/thickness. Separately evaluate the daily crew dose from each radiation component that penetrates the spacecraft windows.

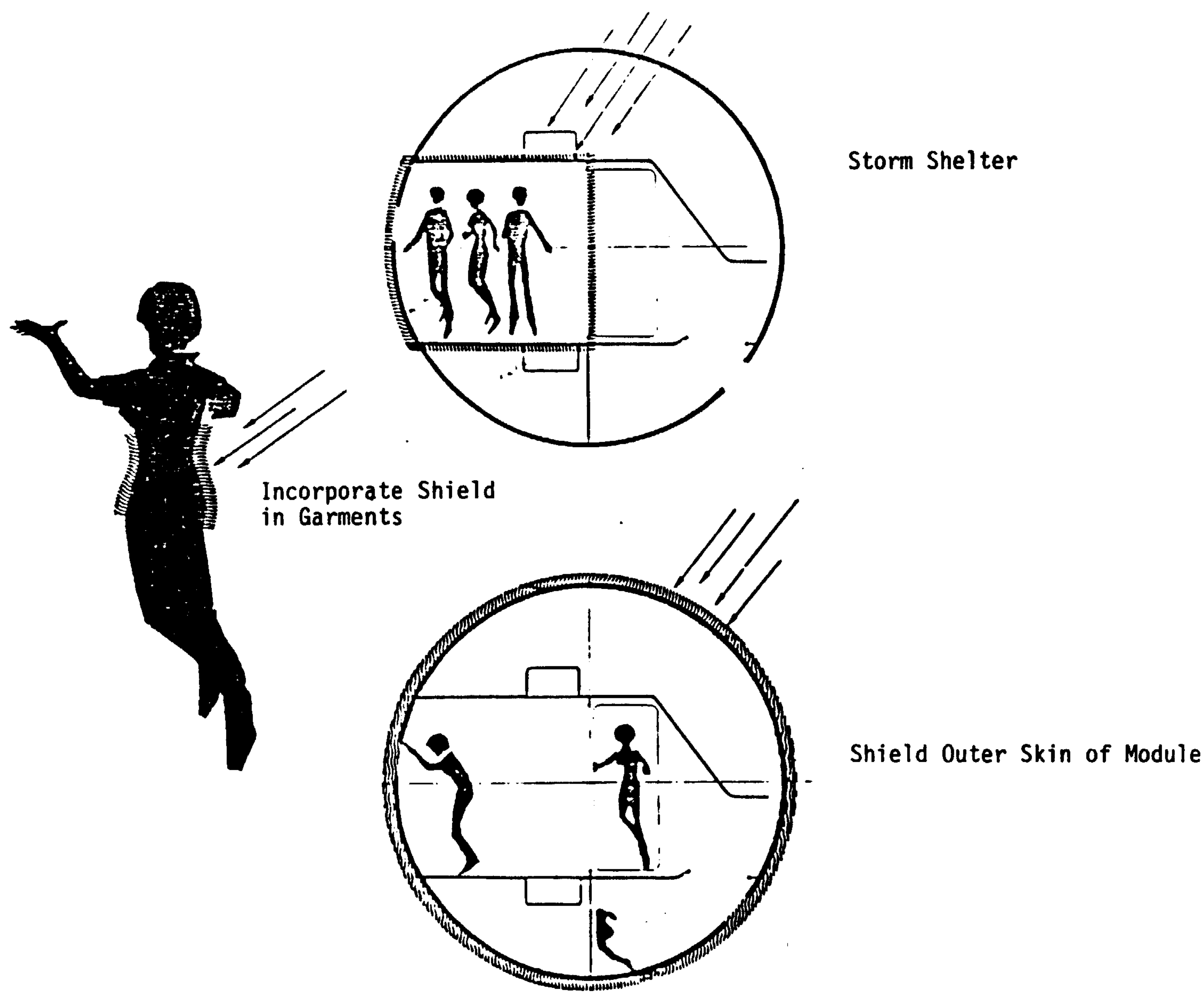

Figure 1. Management Plan 202M02, Options for Distributing Space Station Weight to Shield Crew Members

(09) Select Micrometeorite Shield - Based on the results of Tasks 03 and 08 and on the radiation exposure design limits, select micrometeorite/debris shield material and thickness and coordinate with designers.

(10) Additional Crew Shielding - Based on the results of Tasks 08 and 09 and on the radiation exposure design limits, determine the additional thickness and weight of radiation shielding required (over micrometeorite shield and inherent) to reduce dose rates to acceptable levels and update as design evolves. Consider shielded clothing.

(11) Parametric Dose Reduction - Based on the results of Tasks 08 and 10 and the radiation exposure design limits, perform a parametric shielding study of mass vs crew locations for acceptable total organ dose rates per day.

(12) Minimum Shielding Configuration - Based on the results of Task 11, select the shielding mass locations for the configuration with minimum mass. Determine interface requirements and maintain current as design evolves.

(13) Shielded Storage - Based on mission requirements for film and other radiation-sensitive materials and the results of Task 08, determine the shielded volume and the acceptable radiation level for stored radiosensitive articles.

(14) Shielding for Growth Missions - Using the results of Tasks 01 and 08, determine additional shielding required for planned "growth" missions and maintain current as missions evolve.

(15) Documentation - Document design requirements for Space Station radiation shielding and micrometeorite/debris protection.

SPECIAL STUDY NEEDS:

TASK(S)	NEED
2	Micrometeorite/debris flux-size distribution data
3	Micrometeorite/debris shield material and design data under consideration
7	Spacecraft configuration data
8,11	Spacecraft configuration data, plus mission and crew schedule plan data, plus 3-D space radiation transport and dose code
13	Preliminary mission plans for SS
14	SS growth planning data

SPECIAL SKILLS:

TASK(S)	SKILL
1,4,5,8,10,12	Space Radiation Environment Technology/Codes
2	Micrometeorite/Debris Environment Technology/Code
3	Micrometeorite/Debris Detection Technology/Codes
7,12	SS Configuration

PERFORMING ORGANIZATION:

(01) Managing: NASA Labs: Radiation Shielding - Johnson, Goddard or Marshall; Micrometeorites - JPL or Langley

(02) Doing: WP-01 Aerospace Contractor

STUDY PRODUCTS:

Detailed design specifications for:

(01) Design of radiation and micrometeorite protective shielding systems (additional to inherent structure and windows)

(02) Interfaces of radiation shielding systems with spacecraft structure

(03) Radiosensitive materials storage shielding

(04) Mission growth shielding strategies

PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS:

SUBELEMENT NO. & TITLE		Undefined Rqmt #
20201	RADIATION PARTICLES	-03, -04, -05
20208	MICROMETEORITES	-01
20210	GROWTH	-01

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
202M02	OPTIMAL RADIATION/MICROMETEORITE SHIELDING	07-16-85

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                                       1985       |    1986                          |
                               CALENDAR|O--N--D--|J--F--M--A--M--J--J--A--S--|
                                 FISCAL|FY 86                                      |
                                  MONTH|1  2  3   4  5  6  7  8  9  10 11 12 |
                                PHASE B|                                           |
                                      C|                                           |
STUDY  TASKS                           |                                           |
                                       |D                                          |
1. Exterior Radiation Environment      |---                                        |
                                       |(1 mm)                                     |
2. Micrometeorite Distribution         |---------                                  |
                                       |   (1 mm)                                  |
3. Micrometeorite Shield Materials     |---------                                  |
                                       |   (3 mm)                                  |
4. Bremm Dose from Micrometeorite      |   ------                                  |
   Shields                             |   (1 mm)                                  |
                                       |                                           |
5. Proton Atten. thru Micrometeorite   |          ------                           |
   Shields                             |          (.5 mm)                          |
                                       |                                           |
6. HZE Part. Atten. Thru Micromete-    |          ------                           |
   orite Shields                       |          (1 mm)                           |
                                       |         A                                 |
                                       |         B                                 |
7. Struct. Shielding Config.           |          --------------------------       |
                                       |              (1 mm)                       |
                                       |         C                                 |
8. Parametric Doses thru Shields       |          --------------------------       |
   and Windows                         |               (1.5 mm)                    |
                                       |                                           |
9. Select Micrometeorite Shield        |          -------                          |
                                       |          (2.5 mm)                         |
10. Additional Crew Shielding          |            ------------------------       |
                                       |                     (1.5 mm)              |
11. Parametric Dose Reduction          |                   -----------------       |
                                       |                      (2 mm)               |
12. Minimum Shield Configuration       |                   ------------------|
                                       |                      (1.5 mm)             |
15. Documentation                      |-------------------------------------------|
                                       |                  (3 mm)                   |
```

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
202M02	OPTIMAL RADIATION/MICROMETEORITE SHIELDING	07-16-85

	1986			1987								
CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S
FISCAL	FY 87											
MONTH	1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												

STUDY TASKS	Schedule
Assuming Jan 87 for SDR	
7. (cont)	-------- (.5 mm)
8. (cont)	-------- (.5 mm)
10. (cont)	------------------------------------ (1.5 mm)
11. (cont)	-------- (1 mm)
12. (cont)	------------------------------------ E (3 mm)
13. Shielded Storage	------------------------------ (1.5 mm)
14. Shielding for Growth Missions	------------------------------------ (2 mm)
15. (cont)	-------- (1 mm)

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
202M02	OPTIMAL RADIATION/MICROMETEORITE SHIELDING	07-16-85

	1987			1988								
CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S
FISCAL	FY 88											
MONTH	1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												
STUDY TASKS												
10. (cont)	(1 mm)											
12. (cont)	(1.5 mm)											
14. (cont)	(1 mm)											

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
202M02	OPTIMAL RADIATION/MICROMETEORITE SHIELDING	07-16-85

SUMMARY SCHEDULE/COST FACTORS

STUDY SPAN: OCT 85-APR 88 CM = 31

CATEGORY	FACTOR/MM(CM)*	COST $
LABOR		
- NASA Project Mgmt	10.0 mm	
- Study Mgmt	10.0 mm	
- Study Tasks		
- Analyst, Eng'g	2.0 mm	
- Special Skills:		
-Radiation Transport	22.0 mm	
-Micrometeorite Environment	7.5 mm	
-Spacecraft Configuration	3.5 mm	
SPECIAL FACILITIES		
TRAVEL		
- Coordination w/NASA, Aerospace Co's		
MATERIALS		
TEST PROGRAM		
OTHER (List)		
- Computer Time (BCS)		10 K

* MM = Manmonths; CM = Calendar Months

REPORT FORMAT 13 MANAGEMENT PLAN OVERVIEW

NUMBER	TITLE	DATE
202M03	SOLAR FLARE PROTECTION	07-16-85

ISSUE #	TITLE	NEED DATE
2020501	SOLAR FLARE RISK	JAN 86
2020502	SOLAR FLARE PROTECTION	AUG 86
2020503	SOLAR FLARE CONTINGENCY PLANNING	MAY 88
2020504	SOLAR FLARE WARNING SYSTEM	AUG 86

OBJECTIVES:

(01) Develop criteria for integrating the risk from solar flares with other mission planning requirements.

(02) Develop requirements for solar flare protection measures.

(03) Develop criteria for integrating solar flare contingency planning with other mission planning requirements.

(04) Develop requirements for a solar flare warning system.

BACKGROUND:

Solar activity results in the emission from the sun of a variety of particles and electromagnetic radiation. Most significant, from the viewpoint of spacecraft and crew, are the solar proton events that emit solar cosmic rays consisting mainly of protons and a few percent of alpha and higher Z particles. Solar activity, as measured by the yearly-smoothed sunspot number, has been historically shown to exhibit an 11-year cycle (we are currently nearing the end of the 21st cycle).

Even though the terms "solar flare" and "solar proton event" are often used interchangably, there are a large number of solar flares each year, only a few of which emit protons along with the electromagnetic radiation. During the 7 middle years of a cycle, solar activity is maximum and it is during this period that solar proton events occur most frequently. Nevertheless, there is currently no reliable way to predict solar proton events (Ref.1). From the 19th and 20th cycles, it is known that most major proton events occur within the two to four years following the cycle maximum (Ref. 2). However, they can occur at virtually anytime during the cycle (e.g., a moderate size event occurred on April 24, 1985, yet we are about two years away from the end of the 21st cycle).

From the above it becomes clear that the solar proton hazard should be treated both probabilistically and deterministically. The probabilistic approach would enable bounds on specific hazards to be evaluated. The deterministic approach would specify a design basis solar event, i.e., a worst-case solar proton event for purposes of designing radiation protection design features. It would allow analyses to determine which protection measures to incorporate, given that the design basis solar proton event occurred, (i.e., probability is 1). Included would be the development of contingency plans to

direct crew actions in the event of a solar proton event. Both approaches would also include the altitude and inclination parameters of all anticipated missions, because the earth's magnetic field does shield incoming protons significantly for both low altitude and equatorial orbits.

Another aspect of the solar flare hazard is the consideration of a solar flare warning system (Ref. 3). Although the physical processes within the sun that result in solar proton accelerations are still not well understood, much progress has been made over the last 20 years in recording the effects involved (Ref. 4) (e.g. data collected during the 1980/81 International Solar Maximum Year). This abundance of data has led to the development and testing of many theories for the acceleration of the solar protons. It now appears that solar protons are energized in shocks, and many of these shocks are driven by mass ejections from the corona. Furthermore the data suggests the kind of additional instrumentation needed (real time measurements of the magnetic field on the solar surface and in the corona) from which parameters could be derived for more reliable forecasting of solar flares (Ref. 5).

This issue resolution study will define the requirements for the Space Station solar flare risks, protective measures, contingency plans, and warning system.

INPUTS:

A. Preliminary Space Station design data
B. SHIELDING CONFIGURATION (Issue 2020103)
C. External configuration
D. Laboratory and habitat configuration
E. PERSONNEL DOSIMETRY (Issue 2020102)
F. RADIATION MONITORING SYSTEM (Issue 2020101)
G. Management Plan 306M04 - GROUND SUPPORT FOR LONG-RANGE PLANNING

CRITICAL ASSUMPTIONS:

(01) Even though the orbits for most missions are planned to have altitudes of less than 500 km and inclinations of less than 28.5 deg., there will be other missions with higher altitudes and more polar inclinations for which solar flare protection measures will have to be considered.

(02) The potential hazard from a solar proton event is large enough to warrant consideration of integrating a solar flare warning system as an auxiliary Space Station system.

(03) Space Station usage will extend over at least one solar cycle (11 years) so that the potential hazards of solar protons will have to be considered.

(04) A set of radiation exposure design limits will be developed which will serve as the criteria for many of the study tasks. These design limits will be derived directly from the NASA Space Station ionizing radiation exposure limits.

(05) Milestone dates: RUR2 - Oct 85; IRR - Jan 86; SRR - Apr 86; ISR - Jun 86; SDR - Jan 87; PDR - Jan 88

SPECIAL REMARKS:

(01) The health and safety of the crew shall be maintained by providing protection against very rare events where the radiation levels might result in doses beyond the established radiation exposure design limits. The probability of such an event, the shielding needed to reduce its impact, the warning system needed to signal its onset and the contingency plans needed to deal with it are all the subject of this Management Plan.

(02) The results of this study should be integrated with results of Management Plan 202M02 for complete assessment of shielding design drivers.

REFERENCES:

(01) Solar Terrestial Predictions Proceedings, Vols. 1 and 2, NASA-TM-81061 and NASA-CR-162794, R. Donnelly, Ed., 1979

(02) J.King,"Solar Proton Fluences for 1977-83 Space Missions", J. Spacecraft and Rockets, V.11, p.401, 1974

(03) F. Rayne,"Apollo Spacecraft Nuclear Radiation Protection Status Report", NASA SP-71, Second Symposium on Protection Against Radiations in Space, 1965

(04) R.E. McGuire,"The Composition, Propagation and Acceleration of Energetic Solar Particles: A Review of United States Research 1979-1982", Reviews of Geophysics and Space Physics, V.21, p.305, 1983

(05) D. Rust,"Solar Flares, Proton Showers, and the Space Shuttle," Science, V.216, p.939, 28 May 1982

NUMBER	TITLE	DATE
202M03	SOLAR FLARE PROTECTION	07-16-85

STUDY TASKS:

(01) Solar Proton Event Profile - Based on existing solar proton data, including that for the 21st solar cycle, develop a profile of the probability of a solar cycle, develop a profile of the probability of a solar proton event as a function of the proton fluence magnitude and spectrum and of the mission duration. Use this data to define the design-basis solar event.

(02) Solar Proton Risk Criteria - Based on the results of Task 01, data concerning the existing solar flare detection system, and communication and data integrating network capabilities to support the SS warning system, determine the time available to implement emergency procedures, the range of actions that may be taken as part of these procedures, and criteria for interfacing these procedures with other mission plans and procedures.

(03) Growth Missions - Based on the results of Tasks 01 and 02, to include the effect of geomagnetic shielding, provide estimates of the changes in proton event probabilities, profiles and emergency procedures associated with potential growth missions (beyond the 500 km, 28.5 degree inclination orbit).

(04) External Solar Proton Environment - Based on the results of Task 03 and using appropriate space radiation codes, determine the external radiation environment (solar protons and associated cosmic rays) for orbits of interest for probability of event occurrence.

(05) Solar Proton Doses - Based on the results of Task 04, using an appropriate charged particle transport computer code, and the Space Station shielding configuration, determine the additional radiation doses to unshielded crew organs at different crew locations due to solar protons for the design basis event and as a function of the probability of event occurrence.

(06) Solar Proton Dose Reduction - Based on the results of Task 05 and using an appropriate charged particle transport computer codes, perform a parametric shielding study of additional shielding materials (Z and thickness) needed to reduce the solar proton radiation doses for the design basis event and as a function of the probability of occurrence.

(07) Solar Proton Protection Measures - Based on the results of Task 06, determine the need and requirements for any additional means of protecting crew members from a design basis solar proton event including the prioritization of protection measures such as personnel shielding, a "storm shelter", additional structural shielding, etc.

(08) Warning System Options - Based on a review of the existing solar data network and of the state-of-the-art in solar physics proton acceleration processes, determine the monitoring requirements

for a solar proton warning system including use of: a) existing satellite instrumentation, b) possible future satellite instrumentation providing more continuous solar measurements (e.g., solar x-ray telescopes to track the coronal magnetic field), c) terrestial instrumentation and d) special instrumentation (e.g., telescopes) aboard Space Station.

(09) Warning System Data Requirements - Based on the results of Task 08, determine the data requirements for an integrated solar proton warning system , including a) data entry, retrieval and storage and b) data manipulation, display, and transfer. Update as design evolves.

(10) Warning System Computer Requirements - Based on the results of Task 09, determine the computer hardware and software requirements to support the solar proton warning system.

(11) Emergency Procedures - Based on the results of Tasks 02 and 09, establish an emergency procedure sequence, including a decision-making hierarchy, for the activation of contingency steps necessary to assure crew safety during a solar proton event. Maintain current as design evolves.

(12) Documentation - Document the solar proton event risk and contingency planning criteria and solar proton protection measures and warning system requirements.

SPECIAL STUDY NEEDS:

TASK(S)	NEED
1	Solar proton event data
2,3,11	Preliminary mission plan for Space Station
5,6,7	Spacecraft configuration data
5,6,7	Availability of an operable 3-dimensional space radiation transport code.
8,9	Access to space instrumentation data base which has been developed for use on satellites.
9,10	Availability of scoping criteria for Space Station computer requirements

SPECIAL SKILLS:

TASK(S)	SKILL
4,5,6,7	Space Radiation Transport Analysis
8,9	Space Instrumentation Design
2,3,11	Mission Planning
9,10	Computer System Design

PERFORMING ORGANIZATION:

(01) Managing: NASA Laboratories, e.g., Goddard or Marshall

(02) Doing: WP-01 Aerospace Contractor (Prime)
Other Laboratories (e.g., Space Environmental Laboratory or Air Force Geophysics Laboratory) (Sub)
University Physics and Astronomy Depts (e.g. Univ. of Kansas, Univ. of Maryland, Cal Tech, or Johns Hopkins) (Sub)

STUDY PRODUCTS:

Detailed design specifications for:

(01) Solar flare (proton) risk criteria for mission planning

(02) Solar flare (proton) protection measures

(03) Solar flare (proton) emergency planning strategies

(04) Solar flare (proton) warning system

PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS:

SUBELEMENT NO. & TITLE	Undefined Rqmt #
20205 SOLAR FLARES	-01, -02

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REPORT FORMAT 15                SCHEDULE-TASK FLOW

NUMBER                             TITLE                        DATE
202M03     SOLAR FLARE PROTECTION                               07-16-85

                                      1985     |   1986                 |
                             CALENDAR|O--N--D--|J--F--M--A--M--J--J--A--S--|
---------------------------------------------------------------------------
                               FISCAL|FY 86                                |
                                MONTH|1  2  3   4  5  6  7  8  9  10 11 12 |
---------------------------------------------------------------------------
                              PHASE B|                                     |
                                    C|                                     |
STUDY  TASKS                         |-------------------------------------
Assuming:  Oct 85 for RUR-2          |                                     |
           Jan 86 for IRR            |                                     |
           Apr 86 for SRR            |                                     |
           Jun 86 for ISR            |                                     |
                                     |                                     |
1. Previous Solar Proton Data        |---                                  |
                                     |(2.5 mm)                             |
2. Solar Proton Risk Criteria        |----------                           |
                                     | (2 mm)                              |
3. Growth Missions                   |----------------------------         |
                                     |           (2 mm)                    |
4. External Solar Proton Environment |------                               |
                                     |(1 mm)                               |
5. Solar Proton Doses                |   ------                            |
                                     |   (1.5 mm)                          |
6. Solar Proton Dose Reduction       |         -------                     |
                                     |         (1.5 mm)                    |
7. Solar Proton Protection Measures  |         ------------------          |
                                     |            (2 mm)                   |
8. Warning System Options            |         ------------------          |
                                     |            (3 mm)                   |
9. Warning System Data Requirements  |         ------------------          |
                                     |            (2 mm)                   |
10. Warning System Computer Reqmts.  |         ------------------          |
                                     |            (1.5 mm)                 |
11. Emergency Procedures             |                   --------          |
                                     |                    (2 mm)           |
12. Documentation                    |---------------------------          |
                                     |         (3 mm)                      |
```

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
202M03	SOLAR FLARE PROTECTION	07-16-85

	1986			1987								
CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S
FISCAL	FY 87											
MONTH	1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												

STUDY TASKS

Assuming: Jan 87 for SDR

6. (cont)	(1 mm)
9. (cont)	(1 mm)
11. (cont)	(1 mm)
12. (cont)	(1 mm)

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
202M03	SOLAR FLARE PROTECTION	07-16-85

	1987			1988								
CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S
FISCAL	FY 88											
MONTH	1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												

STUDY TASKS

Assuming: Jan 88 for PDR

6. (cont)	(.5 mm)
9. (cont)	(.5 mm)
11. (cont)	(.5 mm)
12. (cont)	(.5 mm)

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
202M03	SOLAR FLARE PROTECTION	07-16-85

SUMMARY SCHEDULE/COST FACTORS

STUDY SPAN: OCT 85-APR 88 CM = 31

CATEGORY	FACTOR/MM(CM)*	COST $
LABOR		
- NASA Project Mgmt		
- Study Mgmt	10.0 mm	
- Study Tasks		
- Analyst, Eng'g	2.0 mm	
- Special Skills:		
- Radiation Transport Analysis	16.5 mm	
- Computer/Instrumentation Design	7.0 mm	
- Mission Planning	4.5 mm	
SPECIAL FACILITIES		
TRAVEL		
- Coordination w/NASA, Aerospace Co's. & National Labs and University Personnel		
MATERIALS		
TEST PROGRAM		
OTHER (List)		
- Computer Time		4 K

* MM = Manmonths; CM = Calendar Months

REPORT FORMAT 13 MANAGEMENT PLAN OVERVIEW

NUMBER	TITLE	DATE
202M04	HZE PARTICLE PROTECTION	07-19-85

ISSUE #	TITLE	NEED DATE
2020401	HZE PARTICLE PROTECTION FEASIBILITY	OCT 87

OBJECTIVES:

(01) Develop criteria for incorporating protection against HZE particles into the Space Station design.

BACKGROUND:

The potential biological hazards of heavy charged particles (called HZE particles) have been consistently noted during the development of manned space programs. Because the early flights were of short duration the effects of HZE particles were considered minor until the observation of "light flashes and streaks" by the Apollo 11 crew. These light flashes were attributed to the passage of HZE particles through the eye. This refocused attention on the effects of HZE particles.

Many manned spacecraft missions in the 1970's by both the U.S. and the Soviet Union, therefore, carried HZE particle detectors. These consisted primarily of passive detectors, nuclear track-etch plastics, which had to be scanned by electron microscope after the mission to determine characteristics of the HZE particles encountered during the mission. These measurements of recent years, augmented by analysis to theoretically describe the complex interactions taking place, addressed one aspect of the problem, that of characterizing the HZE particle fluxes in space and their interactions.

The second aspect, that of determining the radiobiological effects of the HZE particles, has also been addressed by a large number of experiments in recent years, some in space and some at laboratories with high energy ion accelerators. These workers have noted that one of the unique aspects of the biological effects of HZE particles is that absorbed radiation dose is not a meaningful measure of their effect because a single HZE particle can inactivate a number of cells from the energy deposited. More relevant to the radiation damage caused by an HZE is the term "microlesion" defined as the region of cellular destruction caused by the passage of a single HZE particle (comprised of a "core" region traversed by the HZE particle and a wider region surrounding it composed of the induced delta rays).

There thus exists a large body of recent data developed since the Radiobiological Advisory Panel of the National Academy of Sciences issued, in 1973, its important study and recommendations to NASA on the effects of HZE particles on manned spaceflight. Both the NASA report, and especially the recent measurements, need to be carefully evaluated in order to develop an implementable plan for providing protection against the hazards of HZE particles to the Space Station crew.

INPUTS:

A. Work and living space configuration.
B. SHIELDING CONFIGURATION (Issue 2020103)
C. RADIATION MONITORING SYSTEM (Issue 2020101)
D. PERSONNEL DOSIMETRY (Issue 2020102)
E. Mission duration data

CRITICAL ASSUMPTIONS:

(01) The orbits for which the Space Station missions are planned have altitudes of less than 500 km and inclinations of less than 28.5 degrees.

(02) The duration of Space Station missions will be sufficient to pose potential hazards from HZE particles to crew members.

(03) Space Station usage will extend over at least one solar cycle (11 years) so that the HZE particle contribution of solar cosmic rays needs to be considered.

(04) Milestone Dates: RUR2 - Oct 86; IRR - Jan 86; SRR - Apr 86; ISR - Jun 86; SDR - Jan 87.

SPECIAL REMARKS:

(01) Among the main HZE particle protection measures to be considered is the method and hardware for detecting these particles. Depending on which HZE particle detection system is chosen, the hardware and software may be partially or totally integrated with the overall radiation monitoring system (Management Plan 202M01).

(02) References 01, 02 and 03 must be used when performing this study.

REFERENCES:

(01) HZE-Particle Effects in Manned Spaceflight, D. Grahn, Ed., National Academy of Sciences, 1973.

(02) "Radiation Exposures During Space Flight and Their Measurement," E. Benton and R. Henke in Life Sciences and Space Research, XX (1), Vol. 3 #3, 1983, p 171.

(03) Unique Biological Aspects of Radiation Hazards - An Overview," P. Todd, Life Sciences and Space Research, XX (1), Vol. 3 #8, 1983, p 187.

REPORT FORMAT 14 STUDY PLAN

NUMBER	TITLE	DATE
202M04	HZE PARTICLE PROTECTION	07-19-85

STUDY TASKS:

(01) Exterior HZE Particle Fluxes - Determine the exterior HZE particle fluxes in the projected orbits, based on a review of relevant data, contributed by the following: a) galactic cosmic rays (GCR) and b) solar proton events, also called solar cosmic rays (SCR).

(02) Interior HZE Particle Fluxes - Determine the HZE particle fluxes within the spacecraft, based on a review of relevant shielding data and/or calculations.

(03) HZE Particles on Previous Spacecrafts - Compile and review the measurements of HZE particles made on previous spacecraft missions including information on: passive/active detector, specific sensor type, shielding, location and readout.

(04) Biological Effects of HZE Particles - Compile, review, and remain technically current with the relevant experimental data regarding the biological effects of HZE particles.

(05) HZE Dosimetry - Compile, review, and remain technically current with the latest dosimetric methods for measuring HZE particles including both passive and active types.

(06) Locate Passive HZE Dosimeter - Develop a preliminary plan for the type, location, and number of passive track-etch HZE personnel dosimeters to be deployed and update as technology and design evolves, including: a) which track-etch material to use, b) accuracy, reliability and convenience and c) readout, reset and calibration.

(07) Active HZE Particle Dosimeters - Determine the feasibility of providing active sensors for monitoring HZE particles including: a) if feasible: which sensor technology to use, location and number of interior sensors, need for exterior mounting, electronic system requirements and computer hardware and software requirements; and b) if not feasible: alternatives, reliance on a self-contained passive dosimeter system (on-board readout).

(08) Electronic Requirements - Determine the electronic system requirements for either an active sensor system or a self-contained passive dosimeter system if either are determined to be feasible.

(09) Computer Hardware and Software Requirements - Determine the computer hardware and software requirements and system interfaces to support either an active sensor system or a self-contained passive dosimeter, system if either are determined to be feasible.

(10) Estimate of Crew Risk - Based on 1, 2, and 4 above, provide a preliminary estimate of risk to the crew posed by HZE partiles in a Space Station mission of specified duration.

(11) Additional HZE Monitoring and Protection - Assess the feasibility of additional HZE personnel protection measures (use of on-board animals with known HZE susceptibility, portable personnel shielding).

(12) Documentation - Document the design requirements for the HZE particle detection system, and recommend additional HZE personnel protection measures and the estimate of HZE particle risk to the crew.

SPECIAL STUDY NEEDS:

TASK(S)	NEED
2,3	Access to measurements of HZE particles made on previous spacecraft missions.
5,6,7,8,9	Access to data base of HZE particle dosimetry.
4,10,11	Access to data base of measurements on biological effects of HZE particles.
2	Availability of Space Station configuration data.
2	Availability of radiation transport code for HZE particles.

SPECIAL SKILLS:

TASK(S)	SKILL
3,5,6,7,11	Radiation Dosimetry
4,10,11	Radiobiology, Space Medicine
1,2,11	Radiation Transport Analysis
8,9	Computer/Electronic System Design

PERFORMING ORGANIZATION:

(01) Managing: NASA Laboratories, e.g., Ames (Radiobiology or Langley Physics)

(02) Doing: Aerospace Firms (Prime)
National Laboratories (Sub) (e.g., Lawrence Berkeley Laboratory or Argonne National Lab or Oak Ridge National Lab.)
University Physics Departments (Sub) (e.g., Univ. of San Francisco or Penn State or University of Chicago or University of Nebraska (Radiobiology).

STUDY PRODUCTS:

Detailed design specifications for:

(01) HZE particle detection requirements and other HZE personnel protection measures.

PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS:

SUBELEMENT NO. & TITLE	Undefined Rqmt #
20204 HIGH-Z, HIGH-E PARTICLES	-01,-02

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
202M04	HZE PARTICLE PROTECTION	07-19-85

	1985			1986									
CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S	
FISCAL	FY 86												
MONTH	1	2	3	4	5	6	7	8	9	10	11	12	
PHASE B													
C													
STUDY TASKS													
Assuming: Oct 86 for RUR-2 Jan 86 for IRR Apr 86 for SRR Jun 86 for ISR													
1. Exterior HZE Particle Fluxes	---												(.5 mm) A
2. Interior HZE Particle Fluxes	B---	---	---										E (1 mm)
3. HZE Particles on Previous Space-craft.		---	---										(.5 mm)
4. Biological Effects of HZE particles.						---	---	---	---	---	---	---	(1 mm)
5. HZE Dosimetry	C---	---	---	---	---	---	---	---	---	---	---	---	D (2.5 mm)
6. Locate Passive HZE Dosimeters				---	---	---	---	---	---	---	---	---	(1 mm)
7. Active HZE Particle Dosimeters				---	---	---	---	---	---	---	---	---	(1.5 mm)
8. Electronic Requirements				---									(.5 mm)
9. Computer Hardware and Software Requirements				---	---	---	---	---	---	---	---	---	(1.5 mm)
10. Estimate of Crew Risk							---	---					(2 mm)
11. Additional HZE Monitoring and Protection		---	---	---	---	---	---	---	---	---	---	---	(1.5 mm)
12. Documentation	---	---	---	---	---	---	---	---	---	---	---	---	(2.5 mm)

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
202M04	HZE PARTICLE PROTECTION	07-19-85

```
                                           1986       |   1987                                  |
                                  CALENDAR|O--N--D--|J--F--M--A--M--J--J--A--S--|
                                    FISCAL|FY 87                                               |
                                     MONTH|1  2  3   4  5  6  7  8  9  10 11 12 |
                                   PHASE B|                                                    |
                                         C|                                                    |
STUDY  TASKS                              |
Assuming:  Jan 87 for SDR                 |                                                    |
                                          |                                                    |
4. (cont)                                 |          ----------------------------------------- |
                                          |                   (.5 mm)                          |
5. (cont)                                 |--------------------------------------------------- |
                                          |                  (1.5 mm)                          |
6. (cont)                                 |          ----------------------------------------- |
                                          |                   (.5 mm)                          |
7. (cont)                                 |----------                                          |
                                          | (.5 mm)                                            |
                                          |                                                    |
9. (cont)                                 |--------------------------------------------------- |
                                          |                  (1.5 mm)                          |
                                          |                                                    |
11. (cont)                                |----------                                          |
                                          |  (.5 mm)                                           |
12. (cont)                                |----------                                          |
                                          |  (.5 mm)                                           |
```

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
202M04	HZE PARTICLE PROTECTION	07-19-85

SUMMARY SCHEDULE/COST FACTORS

STUDY SPAN: Oct 85-Oct 87 CM = 15

CATEGORY	FACTOR/MM(CM)*	COST $
LABOR		
- NASA Project Mgmt		
- Study Mgmt	8 mm	
- Study Tasks		
- Analyst, Eng'g	1 mm	
- Special Skills:		
- Radiation Transport Analysis	2 mm	
- Radiation Dosimetry	12.5 mm	
- Space Medicine	4.5 mm	
- Computer/Electronic System Design	4.5 mm	
SPECIAL FACILITIES		
TRAVEL		
- Coordination w/NASA, Aerospace Co's. Radiation Dosimetry People (Natl. Labs)		
MATERIALS		
TEST PROGRAM		
OTHER (List)		
- Computer Time (BCS)		2 K

* MM = Manmonths; CM = Calendar Months

REPORT FORMAT 13 MANAGEMENT PLAN OVERVIEW

NUMBER	TITLE	DATE
202M05	GROUND SUPPORT FOR RADIATION PROTECTION	07-17-85

ISSUE #	TITLE	NEED DATE
2021201	GROUND SUPPORT REQUIREMENTS	JAN 88

OBJECTIVES:

(01) Develop ground computer system requirements and interfaces for support of space radiation dosimetry and record keeping.

(02) Develop ground system requirements for supporting micrometeorite and radiation exposure emergencies (medical, temporary shielding, contingency plan implementation, orbital changes, etc.).

(03) Develop ground system requirements for solar flare particle event warning system.

BACKGROUND:

Orbiting weight can be reduced and reliability increased by reliance on ground support systems, including radiation protection systems. Exterior particle fluxes, interior dose rates and personnel dosimetry readings will be continuously monitored and recorded. The bulk of this data may be advantageously stored in the data bases of ground computers for several reasons. Data storage on-board would be kept to a minimum. The data would be more readily available for prompt analysis and trending by ground support specialists (e.g., adherence to exposure limits, comparison with satellite measurements, etc.). Even more important would be the ability of using large ground computers to rapidly model emergency scenarios involving radiation hazards leading to both an assessment of the potential impact and an evaluation and selection of the optimal solution. Some of the solutions might involve changes with a variety of impacts (temporary shielding, equipment rearrangement, orbital maneuvers, etc.), the total effect of which would be evaluated by computer simulation.

In a similar way, data on micrometeorite fluxes from Space Station instrumentation would be collected in a separate data bank. This data would be continuously updated and would be available for comparison to existing micrometeorite and debris models and for use in modeling the space environment for emergency scenario simulations.

A centralized solar flare warning system is another data network best coordinated on the ground. It might involve several levels of complexity. An observational network already exists jointly sponsored by NOAA Space Environment Laboratory and the Air Force Weather Service via the Space Environment Services Center. It collects and distributes a variety of real-time solar activity data from terrestrial stations and three satellites, and also provides some solar activity predictions. This data would be included in the warning system.

Improved understanding of the proton accelleration mechanisms of the sun are expected to lead to improved forecasting of solar proton events based on the monitoring of additional solar parameters (e.g., magnetic field of the corona) (Ref. 1). Although such specialized monitoring is not currently available, it may be in the future (possibly on Space Station). In this case, this data would also be included in the warning system. Data from other satellites would also be included in the overall warning system which would be manned by solar physicists and supported by large ground computers.

The purpose of this Management Plan is to coordinate and further develop the results of other Management Plans (202M01, 202M02, 202M03, and 202M04) which deal with large radiation protection data bases which can be most effectively utilized through ground support facilities. Management Plans 202M01 and 202M04 deal with the radiation monitoring system. Plan 202M02 deals with radiation and micrometeorite shielding. Plan 202M03 deals with the solar flare warning system and with emergency procedures.

INPUTS:

A. Results of Management Plan 202M01 - RADIATION MONITORING SYSTEM REQUIREMENTS, Study Task 8 - Alocation of Computing Requirements.
B. Results of Management Plan 202M01 - RADIATION MONITORING SYSTEM REQUIREMENTS, Study Task 1 - Exterior Radiation Environment and Task 2 - Interior Radiation Fluxes and Does Rates
C. Results of Management Plan 202M02 - OPTIMAL RADIATION/ MICROMETEORITE SHIELDING, Study Task 2 - Micrometeorite Distribution and Task 8 - Parametric Doses Through Shields and Windows
D. Results of Management Plan 202M03 - SOLAR FLARE PROTECTION, Study Task 8 - Warning System Option
E. Space Station safety plans.

CRITICAL ASSUMPTIONS:

(01) Milestone Dates: SDR - Jan 87; PDR - Jan 88; CDR - Jan 90

SPECIAL REMARKS:

(01) None

REFERENCES:

(01) D. Rust, "Solar Flares, Proton Showers and the Space Shuttle", Science, 216, 28 May 1982, p 939.

REPORT FORMAT 14 STUDY PLAN

NUMBER	TITLE	DATE
202M05	GROUND SUPPORT FOR RADIATION PROTECTION	07-17-85

STUDY TASKS:

(01) Radiation Environment - Determine radiation flux environment, dose rate, and personnel dose records requirements based on the following inputs:

- exterior radiation environment in the SS orbits (from Task 01 or 202M01)
- radiation fluxes and dose rates (from Task 02 of 202M01)
- radiation flux/dose/dose rate data requirements (from Task 06 of 202M01)
- HZE particle fluxes within SS (from Task 02 of 202M04)
- HZE sensor system computer hardware and software requirements (from Task 09 of 202M04)

(02) Micrometeorite/Debris Computing - Determine computer memory and the throughput requirements number for space debris map maintenance/interfaces with other data bases based on the following inputs:

- micrometeorite and debris flux size distribution in the SS orbits (from Task 02 of 202M02)

(03) Ground Support Scope - Determine the scope of ground support to be given micrometeorite and radiation emergencies (e.g., medical, orbit changes, ad-hoc shielding, contingency plans) and determine the decision-making hierachy based on the following inputs:

- results of Tasks 01 and 02, above
- parametric radiation dose rates through the SS radiation shields and windows (from Task 08 of 202M02
- solar flare emergency procedures (from Task 11 of 202M03)

(04) Computing Requirements - Determine the computational throughput and memory requirements for emergency support in each category based on the following inputs:

- results of Task 03, above
- radiation monitoring system computational hardware and software requirements (from Task 07 of 202M01)
- prioritization and allocation of computational requirements for the radiation monitoring system between the ground and space systems (from Task 08 of 202M01)
- HZE sensor system computational hardware and software requirements (from Task 09 of 202M04)

(05) Solar Flare Warning System - Determine the scope of the solar flare warning system and SS ground system interfaces based on the following inputs:

- solar flare warning system options (from Task 08 of 202M03)
- solar flare warning system data requirements (from Task 09 of 202M03)

(06) Solar Flare Computing Requirements - Determine the computational throughput and memory requirements for solar flare support based on the following inputs:

- results of Task 05, above
- solar flare warning system computational hardware and software requirements (from Task 10 of 202M03)

(07) Software Requirements - Based on the results of study Tasks 02, 04 and 06 above determine software requirements needed for ground support.

(08) Hardware Requirements - Based on the results of study Tasks 02, 04 and 06 above determine the hardware requirements need for ground support activities.

(09) Document/Maintain - Document, update and maintain the above requirements.

SPECIAL STUDY NEEDS:

TASK(S)	NEED
1,4	Results of 202M01, Radiation Monitoring System Requirements
1,4	Results of 202M04, HZE Particle Protection
2,3	Results of 202M02, Optimal Radiation/Micro-meteorite Shielding
3,5,6	Results of 202M03, Solar Flare Protection
3,4	Safety Plans

SPECIAL SKILLS:

TASK(S)	SKILL
1,3,4,9	Space Radiation Expertise
4,6,7,8	Computing Requirements Analysis
2	Micrometeorite/Debris Expertise

PERFORMING ORGANIZATION:

(01) Managing: NASA - Marshall (Prime)

(02) Doing: WP-01 Aerospace Contractor (Prime)
Government Laboratories (Sub)

STUDY PRODUCTS:

Detailed design specifications for:

(01) Ground Systems Support, Radiation/Micrometeorite Subsystem.

(02) Computing for (01).

<u>PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS</u>:

<u>SUBELEMENT NO. & TITLE</u>	<u>Undefined Rqmt #</u>
20212 GROUND SUPPORT	-01, -02

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
202M05	GROUND SUPPORT FOR RADIATION PROTECTION	07-17-85

	1986			1987								
CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S
FISCAL MONTH	FY 87 1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												
STUDY TASKS												
Assuming: Jan 87 for SDR												
1. Radiation Environment	---- (2.5 mm)	----										
2. Micrometeorite/Debris Computing				----	----	----	----	---- (4 mm)	----	----	----	----
3. Ground Support Scope	---- (4 mm)	----	----									
4. Computing Requirements				----	----	----	----	---- (5 mm)	----	----	----	----
5. Solar Flare Warning System				----	----	----	----	---- (5 mm)	----	----	----	----
7. Software Requirements									----	----	---- (2 mm)	----
8. Hardware Requirements									----	----	---- (2 mm)	----
9. Document/Maintain	----	----	----	----	----	---- (2 mm)	----	----	----	----	----	----

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
202M05	GROUND SUPPORT FOR RADIATION PROTECTION	07-17-85

	1987			1988								
CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S
FISCAL	FY 88											
MONTH	1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												
STUDY TASKS												
Assuming Jan 88 for PDR												
2. (cont)	------ (2 mm)											
4. (cont)	---------- (4 mm)											
6. Solar Flare Computing Requirements	---------- (4 mm)											
7. (cont)	------------------ (2 mm)											
8. (cont)	---------- (2 mm)											
9. (cont)	-- (1.5 mm)											

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
202M05	GROUND SUPPORT FOR RADIATION PROTECTION	07-17-85

	1988			1989								
CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S
FISCAL	FY 89											
MONTH	1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												
STUDY TASKS												
Assuming Jan 90 for CDR												
9. (cont)	--											
	(1 mm)											

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
202M05	GROUND SUPPORT FOR RADIATION PROTECTION	07-17-85

SUMMARY SCHEDULE/COST FACTORS

STUDY SPAN: OCT 86-SEP 89 CM = 36

CATEGORY	FACTOR/MM(CM)*	COST $
LABOR		
- NASA Project Mgmt		
- Study Mgmt	9 mm	
- Study Tasks		
- Analyst, Eng'g	9 mm	
- Special Skills:		
- Space Radiation Expertise	7 mm	
- Computing Requirements	25.5 mm	

SPECIAL FACILITIES

TRAVEL
- Coordination Trips w/NASA and Laboratories Involved

MATERIALS

TEST PROGRAM

OTHER (List)

* MM = Manmonths; CM = Calendar Months

REPORT FORMAT 13 MANAGEMENT PLAN OVERVIEW

NUMBER	TITLE	DATE
202M06	RADIATION AWARENESS TRAINING	07-17-85

ISSUE #	TITLE	NEED DATE
2020106	RADIATION TRAINING FOR CREW	MAY 89

OBJECTIVES:

(01) Develop appropriate space radiological training objectives, and levels of detail required for each subject area.

BACKGROUND:

There is, among many people, a fear of radiation as an unknown. The Space Station crew will be in an environment which includes both space radiation (ionizing) and induced (non-ionizing) EM radiation. To avoid unwarranted anxieties, the crew should have a thorough and comfortable understanding of the technical aspects of the radiation environments and the associated biological effects (Ref 1).

Except for occasional solar flare proton events, the radiation dose rates for the planned Space Station missions are relatively small. However, effects of cosmic rays are not proportional to average dose rate, but rather to local (cell-level) dose. Furthermore, mission growth, or contingencies, may call for orbits/altitudes in which radiation exposure would be substantially increased. In any case, the crew must know how to operate, calibrate, maintain, read, and interpret data from the radiation monitoring systems for both ionizing and non-ionizing radiations.

Training of the astronauts in space radiation issues will alleviate their personal concerns and prepare them to act appropriately in the event of radiation emergencies. It would also be consistent with the terrestial nuclear industry, especially nuclear power, which requires generalized training for all personnel who may, or will be, entering radiation protected areas, and additional specialized training for those who may have to use protective clothing and/or monitoring equipment. Training in electromagnetic radiation hazards and protection will enable them to avoid and prevent the effects of these radiations.

This issue resolution study will develop the requirements for a radiation awareness training program for the Space Station crews.

INPUTS:

A. Educational profile data of crew - either actual or presumed from personnel requirements
B. RADIATION MONITORING SYSTEM (Management Plan 202M01)
C. GROUND SUPPORT FOR RADIATION PROTECTION (Management Plan 202M05)

CRITICAL ASSUMPTIONS:

(01) Milestone Dates: PDR - Jan 1988; CDR - Jan 1990.

SPECIAL REMARKS:

(01) Even though the orbits for most missiions are planned to have altitudes of less than 500 km and inclinations of less than 28.5 deg., there may be other growth missions with higher altitudes and more polar inclinations which will have to be planned for.

REFERENCES:

(01) Telecon Interview, E. Normand (Boeing Aerospace Co.) with Gerry Carr and Bill Pogue (CAMUS, Inc.), 5 Jun 1985

REPORT FORMAT 14 STUDY PLAN

NUMBER	TITLE	DATE
202M06	RADIATION AWARENESS TRAINING	07-17-85

STUDY TASKS:

(01) Poll Astronauts - Conduct a questionnaire survey of astronauts to ascertain level of understanding of space radiation environment/effects and of electromagnetic radiation hazards, and to obtain opinions about projected level of detail for training. In particular, this would focus on hands-on experience with monitoring instrumentation and on topics either not covered previously or covered in previous training that still remain as points of concern. (Develop survey tool, administer survey, analyze results).

(02) Radiological Content of Astronaut Training Training - Compile and review radiological training materials and content included in the general training of astronauts.

(03) Other Radiation Safety Training - Compile and review training manuals from other ionizing and non-ionizing radiation safety courses for applicability to astronaut training.

(04) Develop Training Objectives - Based on the results of Tasks 01 - 03 and utilizing former astronaut consultants, develop training objectives and course parameters (duration, practical/ theoretical, etc.) and obtain NASA approvals.

(05) Develop Detailed Course Requirements - Based on the results of Task 04, develop the detail course work materials including laboratory work with instrumentation.

SPECIAL STUDY NEEDS:

TASK(S)	NEED
2	Astronaut educational profile data
3	Design specifications for radiation monitoring system.
3	Design specifications for ground systems support, radiation subsystem.

SPECIAL SKILLS:

TASK(S)	SKILL
1	Survey Tool Developer
1	Radiological Expertise
2,3	Radiological Training experience

PERFORMING ORGANIZATION:

(01) Managing: NASA Laboratories

(02) Doing: Aerospace Firms (Prime)
Former Astronaut Consultants (Sub)

STUDY PRODUCTS:

Detailed design specifications for radiation protection training courses.

PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS:

SUBELEMENT NO. & TITLE	Undefined Rqmt #
20201 RADIATION PARTICLES	-06

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
202M06	RADIATION AWARENESS TRAINING	07-17-85

	1987			1988								
CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S
FISCAL	FY 88											
MONTH	1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												
STUDY TASKS												
Assuming Jan 88 for PDR												
1. Poll astronauts											(4 mm)	
										A		
2. Radiological Content of Astronaut Training											(2 mm)	
3. Other Radiation Safety Training											(2 mm)	

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
202M06	RADIATION AWARENESS TRAINING	07-17-85

```
                                        1988        |    1989                                  |
                                CALENDAR|O--N--D--  |J--F--M--A--M--J--J--A--S--               |
                                  FISCAL|FY 89                                                 |
                                   MONTH|1  2  3    4  5  6  7  8  9  10 11 12                 |
                                 PHASE B|                                                      |
                                       C|                                                      |
STUDY  TASKS                            |                                                      |
Assuming Jan 90 for CDR                 |      B                                               |
                                        |      C                                               |
4. Develop Training Objectives          |      -------                                         |
                                        |       (2 mm)                                         |
5. Develop Detailed Course Reqmts.      |             ----------                               |
                                        |                (3 mm)                                |
                                        |                                                      |
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REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
202M06	RADIATION AWARENESS TRAINING	07-17-85

SUMMARY SCHEDULE/COST FACTORS

	STUDY SPAN: JUN 88-MAY 89	CM = 10
CATEGORY	FACTOR/MM(CM)*	COST $
LABOR		
- NASA Project Mgmt	5 mm	
- Study Mgmt	10 mm	
- Study Tasks		
- Analyst, Eng'g		
- Special Skills:		
- Survey Expertise	2 mm	
- Radiological Expertise	11 mm	

SPECIAL FACILITIES

TRAVEL

- To administer/evaluate survey 15 K

MATERIALS

TEST PROGRAM

OTHER (List)

* MM = Manmonths; CM = Calendar Months

REPORT FORMAT 13 MANAGEMENT PLAN OVERVIEW

NUMBER	TITLE	DATE
203M01	NON-IONIZING RADIATION PROTECTION	07-17-85

ISSUE #	TITLE	NEED DATE
2030201	EM LEAKAGE	APR 88
2030202	RF/MICROWAVE EXPOSURE	APR 88
2030401	LASER PROTECTION	APR 88
2030501	SYNERGISTIC INDUCED ENVIRONMENT	APR 88

OBJECTIVES:

(01) Develop interface requirements for all high power electromagnetic (EM) wave emitters (communication, radar, laser, UV/IV/Visible lamps) on or in the Space Station to assure there is no direct or specularly reflected radiation into the interior or habitable spaces.

(02) Develop requirements for attenuation in all Space Station external/internal apertures for all on-board EM transmitted radiations.

(03) Develop EM leakage specifications for all on-board, interior electronic equipment.

(04) Develop design requirements for RF/microwave and IR/Visible/UV field strength monitoring/alerting system.

(05) Develop eyewear and clothing attenuation requirements for laser and UV protection of crew.

BACKGROUND:

Non-ionizing electromagnetic radiation from radio-frequency (RF) or microwave transmitters, and from infrared, visible and ultraviolet lamps and lasers may be hazardous to SS crew health and well-being. Although there is some scholarly controversy as to RF/microwave field strengths required to produce biological effects and as to the nature of the effects, both American National Standards Institute (ANSI) and American Council of Governmental Industrial Hygienists (ACGIH) have established exposure criteria or maximum exposure levels (Refs. 1 and 2). All agree that exposure should be minimized, consistent with the need to use these radiations for benefit. Similarly, ANSI and ACGIH have established exposure standards for lasers (200 nm to 1 mm) and for UV, visible and IR non-laser sources (Refs. 1 and 2). Adherence to these standards for EM exposure is the best way to protect people who work with, or around such EM sources.

The Space Station will have high power RF/microwave sources (radars, communication systems, and lasers) with exterior mounted antennas/exit ports. There will be EM apertures, e.g., windows, through which EM energy can pass into the habitable spaces within the Space Station. Also, there will be electronic equipment and perhaps low-power visible, IR or UV sources within the Space Station that emit

potentially hazardous intensities of EM energy. The National Center for Radiological Devices and Health (NCRDH) has set standards for EM-emitting equipment.

This issue resolution study will develop the means to assure that Space Station crews are not unnecessarily nor excessively exposed to EM radiation.

INPUTS:

A. Space Sattion configuration data showing exterior antenna and laser locations, and showing vehicle shell structure so EM apertures (non-metallic joints) can be located.
B. Space Station interior configuration data showing electronic and other EM source equipment.
C. NASA approval of or modification to ANSI/ACGIH/NCRDH EM safety guidelines.

CRITICAL ASSUMPTIONS:

(01) A set of safety and exposure guidelines applicable to the Space Station will be developed, based on the standards issued by ANSI, ACGIH and NCRDH, for all types of non-ionizing radiation sources expected to be encountered by the crew. These guidelines will need to receive the endorsement of NASA.

(02) Milestone Dates: RUR2 - Oct 85; IRR - Jan 86; SSR - Apr 86; ISR - Jun 86; SDR - Jan 87; PDR - Apr 88

SPECIAL REMARKS:

(01) The passage of ionizing radiation through spaecraft windows is dealt with in Management Plan 202M02, Optimal Radiation/ Micrometeorite Shielding. The attenuation requirements of windows relative to non-ionizing EM radiation are covered in this plan. These separate radiation protection requirements of the windows will have to be coordinated as joint inputs to the design specification.

REFERENCES:

(01) ANSI C95.1, "Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 300 KHz to 100 GHz" 1982

(02) ACGIH "Threshhold Limit Values for Chemical Substances and Physical Agents in the Work Environment" 1985

(03) ANSI Z136.1 "Standards for the Safe Use of Lasers" 1980

NUMBER	TITLE	DATE
203M01	NON-IONIZING RADIATION PROTECTION	07-17-85

STUDY TASKS:

(01) Safety Guidelines - Based on the relevant ANSI, ACGIH and NCRDH EM standards, establish a set of safety and exposure guidelines applicable to Space Station for all of the types of non-ionizing radiation expected to be encountered.

(02) Laser, Radar and Radio Identification - Identify, describe, and classify all lasers, radars and radio communication systems on SS.

(03) Location of FM Sources - From SS preliminary configuration data, determine the locations of all transmitters/lasers, antennas/ laser exit windows, and of all EM apertures in the SS vehicle.

(04) EM Coupling - Based on the sources of Task 03, and using the appropriate EM coupling computer codes, determine EM coupling of all on-board external source fields to SS internals, and the resulting internal field levels in every habitable compartment.

(05) Aperture Attenuation Requirements - Based on the apertures of Task 03, the EM fields of Task 04 and the safety limits of Task 01, use the appropriate computational techniques to determine attenuation requirements for each aperture/window. Establish and maintain those requirements in the interface requirements or specification documents.

(06) Internal EM Source Location - Using internal configuration data, determine the locations of all internal EM sources; and describe them (power, duty cycle, frequencies, etc.).

(07) EM Leakage Levels - Using the exposure guidelines of Task 01 and the results of Task 06, determine the EM field/power density/irradiance leakage levels at the exterior of all internal EM sources.

(08) EM Leakage Specification - Using the results of Task 07 and appropriate computational techniques, determine the EM source leakage specifications (field strength as function of distance from the source) for all internal EM sources. Maintain this data through the evolution of the design and provide them as inputs to EM compatability and interference plans.

(09) EM Hazard Analysis - Using the results of Tasks 04, 05, and 08, perform a systematic failure modes and effects analysis to evaluate the hazards resulting from all radar, laser, UV-VIS-IR sources. Update as design evolves.

(10) Personnel Protection Devices - Using the exposure criteria of Task 01 and the hazards from Task 09, determine personnel protective device requirements (eyewear, clothing). This may

require iteration between measures to limit EM leakage fields and use of additional protection devices to evaluate the tradeoffs involved.

(11) EM Monitoring Requirements - Based on the results of Tasks 01, 04, 05, 08 and 09, determine the requirements for EM field/irradiance monitoring and alerting system in SS: sensor locations, threshold intensity levels, etc.

(12) Safety Plans for EM Sources - Based on mission plans, determine the constraints on safety-related EM source equipment automatic power shut-off; provide input to safety plans for safe operation of EM sources, and update as needed.

(13) Equipment/Module Growth Plans - Obtain/document plans for the future addition of other spacecraft modules and equipment (SS growth plans) and update as needed.

(14) EM Hazards from Additional Equipment - Based on the results of the hazards analysis from Task 09, including the possible need to expand that analysis, determine the EM hazards to the crew due to other additional spacecraft modules or additional equipment. Update as the growth plans evolve.

(15) Documentation - Document the design requirements and specifications for all non-ionizing radiation sources.

SPECIAL STUDY NEEDS:

TASK(S)	NEED
1,2	SS equipment list, configuration data
3	SS preliminary configuration data, vehicle design data.
6	SS preliminary internal configuration data/equipment list.
7,10	NASA approval of, or modifications to, ANSI/ACGIH exposure standards.
12	Mission preliminary planning.
13	Growth preliminary planning.

SPECIAL SKILLS:

TASK(S)	SKILL
All	Expertise in EM Hazards and Protection
4,5	EM Coupling Analysis, Applicable Computer Codes
7,10	Expertise with Current Occupational Safety Standards and EM Exposure Criteria

PERFORMING ORGANIZATION:

(01) Managing: NASA Laboratories

(02) Doing: Aerospace WP-01 Contractor (Prime)
Government Labs (NIOSH, Taft Labs, U.S. Army Environ-

mental Hygiene Agency or Brooks Air Force Base)

STUDY PRODUCTS:

Detailed design specifications for:

(01) High power radio/radar/laser system interfaces.

(02) SS vehicle exterior aperture/window attenuation.

(03) SS internal electronic and EM source leakage specifications.

(04) EM intensity monitor/alert system.

(05) Safe operation of EM sources.

PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS:

SUBELEMENT NO. & TITLE		Undefined Rqmt #
20302	INDUCED ENVIRONMENT - ELECTROMAGNETIC	-01,-03
20304	INDUCED ENVIRONMENT - LASER	-01
20305	INDUCED ENVIRONMENT - GROWTH	-01

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
203M01	NON-IONIZING RADIATION PROTECTION	07-17-85

```
                                          1985         |   1986                                    |
                                 CALENDAR|O--N--D--|J--F--M--A--M--J--J--A--S--|
                                   FISCAL|FY 86                                 |
                                    MONTH|1  2  3   4  5  6  7  8  9  10 11 12  |
                                  PHASE B|                                      |
                                        C|                                      |
STUDY  TASKS                             |                                      |
Assuming:  Oct 85 for RUR-2              |                                      |
           Jan 86 for IRR                |                                      |
           Apr 86 for SSR                |                                      |
           Jun 86 for ISR                |          C                           |
1. Safety Guidelines                     |          -------                     |
                                         |          (.5 mm)                     |
                                         |          A                           |
                                         |          B                           |
2. Laser, Radar and Radio Ident.         |          -------                     |
                                         |          (3.5 mm)                    |
3. Location of EM Sources                |          -------                     |
                                         |          (2 mm)                      |
4. EM Coupling                           |                 ------------         |
                                         |                   (4 mm)             |
5. Aperture Attenuation Reqmts.          |                            ----------|
                                         |                              (1 mm)  |
6. Internal EM Source Location           |          ------                      |
                                         |          (2 mm)                      |
7. EM Leakage Levels                     |                 ----------           |
                                         |                   (2 mm)             |
8. EM Leakage Specifications             |                             ---------|
                                         |                              (1 mm)  |
9. EM Hazards Analysis                   |                             ---------|
                                         |                              (1 mm)  |
                                         |                                      |
11. EM Monitoring Requirements           |                             ---------|
                                         |                              (2 mm)  |
                                         |                                      |
13. Eqpt/Module Growth Plans             |                             ---------|
                                         |                              (1 mm)  |
                                         |                                      |
15. Documentation                        |           ---------------------------|
                                         |                   (2 mm)             |
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REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
203M01	NON-IONIZING RADIATION PROTECTION	07-17-85

```
                                        1986        |    1987                                   |
                              CALENDAR |O--N--D--  |J--F--M--A--M--J--J--A--S--                 |
---------------------------------------------------------------------------------------------------
                                FISCAL |FY 87                                                   |
                                 MONTH |1  2  3    4  5  6  7  8  9  10 11 12                   |
---------------------------------------------------------------------------------------------------
                               PHASE B |                                                        |
                                     C |                                                        |
STUDY  TASKS                           |                                                        |
---------------------------------------------------------------------------------------------------
Assuming:  Jan 87 for SDR              |                                                        |
                                       |                                                        |
5. (cont)                              |--------------------------------------------------------|
                                       |                    (4 mm)                              |
8. (cont)                              |--------------------------------------------------------|
                                       |                 (3.5 mm)                               |
9. (cont)                              |--------------------------------------------------------|
                                       |                    (5 mm)                              |
10. Personnel Protection Devices       |      -------------------------                         |
                                       |                  (4 mm)                                |
11. (cont)                             |-------                                                 |
                                       |(1.5 mm)                                                |
12. Safety Plans for EM Sources        |--------------------------------------------------------|
                                       |                    (3.5 mm)                            |
13. (cont)                             |---------                                               |
                                       |(1.5 mm)                                                |
14. EM Hazards from Added Eqpt.        |-------------------------                               |
                                       |          (3 mm)                                        |
15. (cont)                             |--------------------------------------------------------|
                                       |                    (2 mm)                              |
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REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
203M01	NON-IONIZING RADIATION PROTECTION	07-17-85

```
                                    1987        |   1988                                   |
                           CALENDAR|O--N--D--|J--F--M--A--M--J--J--A--S--|
                             FISCAL|FY 88                                  |
                              MONTH|1  2  3   4  5  6  7  8  9  10 11 12 |
                            PHASE B|                                       |
                                  C|                                       |
STUDY  TASKS                       |                                       |
Assuming:  Apr 88 for PDR          |                                       |
                                   |                                       |
5. (cont)                          |-------------------                    |
                                   |      (1 mm)                           |
8. (cont)                          |-------------------                    |
                                   |      (1 mm)                           |
9. (cont)                          |-------------------                    |
                                   |      (1 mm)                           |
12. (cont)                         |-------------------                    |
                                   |      (1 mm)                           |
```

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
203M01	NON-IONIZING RADIATION PROTECTION	07-17-85

SUMMARY SCHEDULE/COST FACTORS

STUDY SPAN: JAN 86-APR 88 CM = 27

CATEGORY	FACTOR/MM(CM)*	COST $
LABOR		
- NASA Project Mgmt		
- Study Mgmt	10 mm	
- Study Tasks		
- Analyst, Eng'g	6 mm	
- Special Skills:		
- EM Hazards	30 mm	
- EM Coupling Analysis	12 mm	
- EM Safety Standards	6 mm	
SPECIAL FACILITIES		
- EM Aperture Coupling Computer Codes (existing)		
TRAVEL		
- Coordinatin w/NASA Aerospace Co's and supporting government labs		6 K
MATERIALS		
TEST PROGRAM		
OTHER (List)		
- Computer Time		12 K

* MM = Manmonths; CM = Calendar Months

REPORT FORMAT 13 MANAGEMENT PLAN OVERVIEW

NUMBER	TITLE	DATE
204M01	PHYSIOLOGICAL EFFECTS OF LIGHT	25 JUNE 85

ISSUE #	TITLE	NEED DATE
2040101	PHYSIOLOGICAL EFFECTS OF LIGHT	88/06/01

OBJECTIVES:

(01) Identify the effects of the short periodicity (approximately 1.5 hours rather than 24 hours) of the Space Station's light/dark cycle upon the mood and physical and mental alertness of the crew.

(02) Develop alternative approaches to counteract the effects of the short periodicity, including full spectrum interior lighting, special diets, and medication.

BACKGROUND:

Research has indicated that variations in the length of time that humans are exposed to natural light have an influence upon their functioning (1). Mood and behavioral changes occur because of hormonal and neurotransmitter changes (2). Evidence indicates that, through the action of the pineal gland, where light acts as a suppressor agent to melatonin production, absence of light is associated with symptoms of mental depression as well as with a slowdown in behavior and increased tendency to sleep (2,3,4). In addition to the changes observed, there may be more profound higher-order physiological and behavioral changes which have not yet been identified.

Research has indicated that exposing humans to high levels of light generated by a bank of about eight full spectrum fluorescent tubes at close range (1000 Lux) has negated the effects of the production of these depressive conditions (2). However, the solution may be impractical for Space Station crewmembers due to glare or inability to read LEDs or instrumentation having low light levels, and these solutions may be unnecessary if alternative approaches were available to counteract the melatonin entrainment.

An alternative approach that provides high intensity broad spectrum light for short durations may effectively suppress melatonin. There is limited evidence that when delivery of high intensity light of several milliseconds duration corresponds with certain phases of dis-synchronization of internal functioning, melatonin and negative physiological changes are suppressed (5). The operational implication of this is that since light wattage per se for a given span of time may not be as critical as the timing of light delivery, large savings in power requirements may be possible. Empirical determination of

specific light intensities, frequencies, and duration, along with exposure timing would provide the basis for developing lighting specifications that would result in significant energy savings.

This issue resolution plan examines the effect of light upon the production of melatonin and related physiological and psychological effects, and it provides an approach for reducing unnecessary power requirements for lighting.

INPUTS:

A. WORK AND LIVING AREA LIGHTING CHARACTERISTICS

- Intensity
- Wavelength

B. ORBITAL ALTITUDE AND CHARACTERISTICS DETERMINING NATURAL LIGHT PERIODICITY

C. SHIFT OPTIONS (ISSUE #3060102)

D. SHIFT EFFECTS ON PERFORMANCE (ISSUE #3060111)

CRITICAL ASSUMPTIONS:

(01) The 90 day Space Station missions are of sufficient length for these melatonin-related behavioral and hormonal changes to occur.

(02) The behavioral changes discussed above would negatively impact upon the Space Station mission.

(03) Use of intense full spectrum lighting as the deterrent approach could adversely affect crew productivity on the Space Station, especially where vision is difficult due to glare or inability to read electrically luminated dials of low light intensities. In addition, the higher power consumption required is an adverse design impact, for it decreases power availability for Space Station experiments.

SPECIAL REMARKS:

(01) The effects of light on calcium absorption is examined in Issue #2070109, Decreased Calcium Absorption Countermeasures.

REFERENCES:

(01) A.J. Lewy, "Effects of Light on Human Melatonin Concentration and the Human Circadian System." Sleep and Mood Disorders Laboratory, Oregon Health Sciences University, Portland, OR.

(02) A. J. Lewy, H.A. Kern, N. E. Rosenthal, and T. A. Wehr "Bright Artificial Light Treatment of a Manic-Depressive Patient with a Seasonal Mood Cycle." American Journal of Psychiatry, Nov. 1982.

(03) N. E. Rosenthal, D. A. Sack, C. J. Carpenter, B. L. Barry, W. B. Mendelson, and T. A. Wehr. "Antidepressant Effects of Light in Seasonal Affective Disorder." American Journal of Psychiatry, February 1985.

(04) A. J. Lewy, T. A. Thomas, F. K. Goodwin, D. A. Newsome, and S. P. Markey, "Light Suppresses Melatonin Secretion in Humans," Science, 210, Dec. 1980.

(05) Personal communication with Dr. Chuck Winget, NASA Ames, Moffett Field, CA., June 1985.

REPORT FORMAT 14 STUDY PLAN

NUMBER	TITLE	DATE
204M01	PHYSIOLOGICAL EFFECTS OF LIGHT	25 JUNE 85

STUDY TASKS:

(01) Conduct a literature review to establish the known effects of light and day length, light duration and light frequencies upon melatonin suppression and human performance. Consult with subject matter experts within NASA, universities, National Institute of Mental Health, Illumination Engineering Group of the National Bureau of Standards, and the Vision Committee of the National Academy of Sciences.

(02) Review and analyze previous mission data to examine the effects of light periodicity upon crew performance, including interviews with astronauts, and review of filmed performance in space.

(03) Review Space Station lighting characteristics and natural light availability data.

(04) Conduct limited, focused research to identify the optimal duration(s), intensity(ies), frequency(ies) and timing (relative to dis-synchronization of internal functioning) of light exposure required to suppress the production of melatonin and improve physiological/behavioral performance.

(05) Determine the specific effects of variations in the previously determined optimum light characteristics and administration schedule (relative to circadian functioning) upon melatonin suppression and the proficiency with which representative space station tasks are performed.

(06) Conduct research to identify alternative approaches to improve performance or suppress melatonin production, including specific diets, exercise, and medication.

(07) Review Space Station shift options/shift effects data.

(08) Conduct trade studies to select optimal approach to suppress melatonin or improve physiological or behavioral functioning. The trades should consider the following evaluation factors:

a) Design Impact

- Power
- Weight
- Volume
- Complexity
- Technology availability
- Capability to accommodate growth
- Lighting specifications (glare, spectral energy distribution)

b) Operations Impact

- Crew performance
- Crew time
- Procedural complexity
- Interference with other operations

c) Cost

- Development cost
- Life cycle cost

d) Other Factors

- Effectiveness in counteracting physiological and behavioral effects of chronic melatonin production
- Safety
- Reliability
- Maintainability
- Crew acceptability

(9) Analyze research on alternative approaches

(10) Develop plan for on-orbit Space Station validation of the effects of light upon melatonin suppression and physiological/behavioral performance that were observed under one-g conditions.

SPECIAL STUDY NEEDS:

TASK(S)	NEED
2,3	Access to physiological and mission operations data from previous space missions.
4,5,6,8,9	Access to current Space Station design data, especially power system, crew compartment layouts workstation design, task analysis information and window locations.
4,5,6,8	Identification and simulation/employment of space station tasks and task conditions that are most likely to be adversely affected by the production of melatonin.
9	Space Station observation/experimentation/verification
4,5,6,8,9	Performance assessment tests and protocols.

SPECIAL SKILLS:

TASK(S)	SKILL
1,2,3,4,5,6,7,8	Physiological Psychologists, Psychologists Specializing in Visual Psychophysics and Human Performance

1,2,4,5,6,7,8,9	Human Factors Specialist/Biomedical Engineers
5	Illumination Engineers

PERFORMING ORGANIZATION:

(01) Managing

NASA/ARC Life Sciences

(02) Doing

National Institute of Mental Health (prime)

Universities (sub)

Consultants (sub)

National Bureau of Standards (sub)

National Academy of Sciences/Vision Committee (sub)

STUDY PRODUCTS:

(01) Literature review which identifies the nature and magnitude of the effects of light periodicity upon human performance.

(02) Knowledge of the interrelationships between lighting characteristics (intensity, spectral frequencies and duration), circadian cycle, melatonin suppression/production, physiological and psychological changes, and task proficiency for one-g environments.

(03) Research report indicating the difference in the physiological state of the crew members during periods when the space vehicle was not illuminated by the sun (night) and during the day.

(04) Detailed specifications identifying means for eliminating photoperiodicity effects upon performance: Space station lighting characteristics, timing and duration of lighting, or specific diet, exercise or medication that reduces or negates the effect of the production of melatonin.

(05) Effect of spectral energy distribution on performance.

PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS:

SUBELEMENT NO. & TITLE		Undefined Rqmt #
20401	Illumination and Distribution Reqts	-03

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
204M01	PHYSIOLOGICAL EFFECTS OF LIGHT	25 JUNE 85

	1984			1985								
CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S
FISCAL	FY 85											
MONTH	1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												

STUDY TASKS

1. Conduct literature review — 2 mm
2. Review & analyze previous mission data — 3 mm
3. Review space station lighting characteristics and natural light availability data — A, B — 2 mm

C-3

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
204M01	PHYSIOLOGICAL EFFECTS OF LIGHT	25 JUNE 85

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                                         1985         :    1986                                  :
                                 CALENDAR:O--N--D--:J--F--M--A--M--J--J--A--S--:
                                   FISCAL:FY 86                                                  :
                                    MONTH:1   2   3    4   5   6   7   8   9   10  11  12 :
                                  PHASE B:                                                       :
                                        C:                                                       :
STUDY  TASKS                             :                                                       :
                                         :                                                       :
2.  Review & analyze previous mission:-------                                                    :
    data                                 : 3 mm                                                  :
                                         :                                                       :
4.  Collect research data of             :                                                       :
    interrelationships between           :                                                       :
    variables                            :-------------------------------------------------------:
                                         :                 25 mm                                 :
5.  Determine interrelationships         :                                                       :
    among variables                      :                                                       :
                                         :                                              -------:
6.  Conduct research on alternative      :                                               3 mm   :
    approaches                           :-------------------------------------------------------:
                                         :                 25 mm                                 :
7.  Review Space Station shift           :                                                       :
    options/shift effects data           :          C.D----------                                :
                                         :                 2 mm                                  :
                                         :                                                       :
                                         :                                                       :
                                         :                                                       :
                                         :                                                       :
```

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
204M01	PHYSIOLOGICAL EFFECTS OF LIGHT	25 JUNE 85

	1986			1987									
CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S	
FISCAL	FY 87												
MONTH	1	2	3	4	5	6	7	8	9	10	11	12	
PHASE B													
C													
STUDY TASKS													
4. Collect research data of interrelationships between variables	---	---	---	---	---	---	---	---	---	---	---	---	25 mm
5. Determine interrelationships among variables	---	---	---	---	---	---	---	---	---	---	---	---	12 mm
6. Conduct research on alternative approaches	---	---	---	---	---	---	---	---	---	---	---	---	25 mm
8. Conduct trade studies								---	---	---	---	---	6 mm

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
204M01	PHYSIOLOGICAL EFFECTS OF LIGHT	25 JUNE 85

	1987			1988								
CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S
FISCAL	FY 88											
MONTH	1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												

STUDY TASKS	Schedule
9. Analyze research on alternative approaches	O–M (months 1–8): 18 mm
8. Conduct trade studies (including latest research findings); select optimal approach for 1988	O–M (months 1–8): 12 mm
10. Develop Space Station validation plan	F–M (months 5–8): 4 mm

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
204M01	PHYSIOLOGICAL EFFECTS OF LIGHT	25 JUNE 85

SUMMARY SCHEDULE/COST FACTORS

STUDY SPAN: JULY 85-MAY 88 CM = 34

CATEGORY	FACTOR/MM(CM)*	COST $
LABOR		
- NASA Project Mgmt		
- Study Mgmt	17	
- Study Tasks		
- Analyst, Eng'g	14	
- Special Skills:		
Physiological Psychologist/Res. Ps	95	
Human Factors Spec./Biomed. Engr.	41	
SPECIAL FACILITIES		
TRAVEL		
Coordination of NASA, NIH, and University Research Programs	20 K	
MATERIALS		
Test Program Materials	25 K	
TEST PROGRAM		
Test Subjects	10 K	
Research Test Set-up	50 K	
OTHER (List)		

* MM = Manmonths; CM = Calendar Months

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OF POOR QUALITY

REPORT FORMAT 13 MANAGEMENT PLAN OVERVIEW

NUMBER	TITLE	DATE
205M01	PREDICTION OF LOW FREQUENCY NOISE	6-26-85

ISSUE #	TITLE	NEED DATE
2050101	PREDICTION OF LOW FREQUENCY NOISE	Sep 86

OBJECTIVES:

(01) Establish a method to predict Space Station module low frequency (1 Hz to 100 Hz) acoustic noise characteristics based on shape and size and containment of sound-diffusing and sound-absorbing objects and surfaces. Sound sources radiation will be related to the room acoustics so that room noise level can be predicted.

BACKGROUND:

Interior noise criteria for comfort, communication and hearing conservation are nominally established in the audible range of acoustic frequencies (31.5 Hz to 15K Hz). Sub-audible or infrasonic noise of sufficient level is known to produce physiological effects which could affect crew productivity. Some of the symptoms of excessive low frequency noise exposure are: nausea, dizziness, fatigue, headache, soreness in joints, tinitus, disorientation and fainting. These symptoms can also be related to problems experienced by astronauts during long periods of weightlessness.

There is no transmission of acoustic energy from a space craft into the vacuum of space, therefore the acoustic energy generated in each SS module must be absorbed or transformed by the materials within each module. Low frequency noise is a particular problem, since very little acoustic energy is absorbed by conventionally used noise-control materials at those frequencies. Consequently, multiple reflected or reverberant noise levels in a SS module will be significantly greater in space, relative to an Earth atmosphere.

It is important that Space Station noise prediction procedures extend down into the infrasonic range. There is an inadequate data base concerning low-frequency acoustic materials absorption coefficients, wall transmission loss, and generic equipment noise spectra levels to set valid specifications for interior design guidelines.

This issue resolution management plan provides a technical approach for developing interior acoustic design guidelines and specifications for frequencies less than 100 Hz.

INPUTS:

A. WORK AND LIVING SPACE CONFIGURATIONS
B. INTERIOR MATERIALS AND EXPOSED SURFACE AREAS
C. ACTIVITY AREA VOLUMES AND DIMENSIONS
D. LISTING OF COMPARTMENT NOISE SOURCES AND LOCATIONS

CRITICAL ASSUMPTIONS:

(01) A low-frequency acoustic test facility and large vacuum chamber are available to verify the low frequency noise prediction method.

SPECIAL REMARKS:

(01) A normal earth atmosphere within the Space Station shall be assumed.

(02) This study will interrelate with Management Plan 205M02 - Low Frequency Noise Control

(03) Refer to References 01 and 02 during the execution of this study.

REFERENCES:

(01) Hill, R. E., "Space Shuttle Orbiter Crew Compartment Acoustic Noise-Environments and Control Considerations", Rockwell International Space Transportation Systems Division, ASA 108th Meeting (Paper Y2), October 10, 1984

(02) Bolt, Beranek and Newman, Inc.," Recommendations for Noise Levels in the Space Shuttle" (by K. S. Pearson) BBN Job No. 157160 Prepared for NASA JSC, Feb. 28, 1975

NUMBER	TITLE	DATE
205M01	PREDICTION OF LOW FREQUENCY NOISE	6-26-85

STUDY TASKS:

(01) Conduct Literature Review - Conduct a literature review to determine the methods in current use to predict low frequency sound source generation, room acoustic modes and room reverberation characteristics.

(02) Perform Analytical Study - Determine the room resonant modes and air volume characteristics at frequencies below cutoff for a typical Space Station module size and shape. A range of room absorption coefficients shall be assumed. Room reverberation response shall be calculated as a function of frequency.

(03) Develop Low-Frequency Prediction Methods - Establish a method to predict low frequency noise levels in a Space System module.

(04) Evaluate and Verify Prediction Method - Measure air volume acoustic modes and reverberent characteristics and check against predictions using a generic pressurized Space Station module in a large vacuum chamber. The low-frequency prediction methods shall be modified if necessary.

(05) Design Specifications - Design specifications for the low frequency prediction method shall be formulated.

SPECIAL STUDY NEEDS:

TASK(S)	NEED
2	Availability of Space Station configuration data
3,5	Access to a computer
4	Large vacuum chamber, SS module mockup test instrumentation

SPECIAL SKILLS:

TASK(S)	SKILL
2,3,4,5	Acoustics specialist(s)
4	Test engineer

PERFORMING ORGANIZATION:

(01) Managing: NASA - Langley Research Center

(02) Doing: WP-01 Aerospace Contractor

STUDY PRODUCTS:

(01) Low frequency noise prediction method suitable for Space Station modules.

(02) Inputs to design requirements concerning compartment shape and size, choice of materials and equipment (noise source) locations.

PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS:

SUBELEMENT NO. & TITLE	Undefined Rqmt #
20501 Noise Control	-04

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
205M01	PREDICTION OF LOW FREQUENCY NOISE	6-26-85

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                                         1985       |     1986                          |
                               CALENDAR|O--N--D--|J--F--M--A--M--J--J--A--S--|
                                 FISCAL|FY 86                                        |
                                  MONTH|1  2  3   4  5  6  7  8  9  10 11 12 |
                                PHASE B|                                             |
                                      C|                                             |
STUDY  TASKS                           |                                             |
Assuming Dec 86 for SDR                |                                             |
                                       |                                             |
1. Conduct Literature Review           |----                                         |
                                       |(2 m/m)                                      |
                                       |  A                                          |
                                       |  B                                          |
                                       |  C                                          |
2. Perform Analytical Study            |  D-----------                               |
                                       |    (3 m/m)                                  |
3. Develop Low Frequency Prediction    |            ------                           |
   Methods                             |            (2 m/m)                          |
4. Evaluate and Verify Prediction      |                  ------------               |
   Methods                             |                   (8 m/m)                   |
5. Design Specifications               |                              -------|
                                       |                             (1 m/m)|
                                       |                                             |
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REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
205M01	PREDICTION OF LOW FREQUENCY NOISE	6-26-85

SUMMARY SCHEDULE/COST FACTORS

STUDY SPAN: OCT 85-SEP 86 CM = 12

CATEGORY	FACTOR/MM(CM)*	COST $
LABOR		
- NASA Project Mgmt	4.0 mm	
- Study Mgmt	4.0 mm	
- Study Tasks		
- Analyst, Eng'g		
- Special Skills:	12.0 mm	
- Acoustic Test Eng.	4.0 mm	
SPECIAL FACILITIES		
- Low Frequency Test Facility	2 cm	
- Full Scale Vacuum Chamber	1 cm	
TRAVEL		
- Coordination w/NASA, SSP design		15 K
MATERIALS		
- Full Scale Generic Mockup for Vacuum Chamber		75 K
TEST PROGRAM		
- Test Materials		5 K
OTHER (List)		

* MM = Manmonths; CM = Calendar Months

REPORT FORMAT 13 MANAGEMENT PLAN OVERVIEW

NUMBER	TITLE	DATE
205M02	LOW FREQUENCY NOISE CONTROL	6-26-85

ISSUE #	TITLE	NEED DATE
2050102	LOW FREQUENCY NOISE CONTROL	SEP 86

OBJECTIVES:

(01) Devise and evaluate low frequency noise control materials, systems, and control methods to control low-frequency acoustic noise in space module living and working spaces within limits conducive to human confort, safety, and health during long confinement under zero-g conditions.

BACKGROUND:

Low frequency sound is omnipresent. Although the human ear does not readily detect it, the ambient noise spectrum is usually dominated by energy at the low end of the spectrum. Very frequently the levels of low frequency noise are enough to cause extreme discomfort, distress and decline in human productivity. Low frequencies referred to in this issue are below 100Hz, including the infrasound region between 1Hz and 20Hz.

Low-frequency sound control is a problem (Reference 1) since acoustic energy cannot be transmitted through the walls into the vacuum of space, see Figure 1. Low frequency sound wave lengths traditionally require prohibitively thick acoustic absorbent material treatment to adequately transform acoustic energy into heat energy. In order to control low-frequency noise build-up because of repeated reflections of trapped acoustic energy within the Space Station modules, it will be necessary to predict noise levels (Reference 2) (Management Plan 205M01), establish equipment and design specifications (Management Plan 220M01), and determine economical methods for absorbing or negating acoustic energy.

This issue resolution management plan provides technical approach for developing low-frequency noise control guidelines. It also addresses design features which are economical in weight and volume requirements for reducing or containing low frequency noise energy.

INPUTS:

A. WORK AND LIVING SPACE CONFIGURATIONS AND DIMENSIONS
B. ACTIVITY AREA VOLUMES (MANAGEMENT PLAN 101M01)
C. HABITABILITY INTERIOR MATERIALS SELECTION REQUIREMENTS (MANAGEMENT PLAN 104M01)
D. EQUIPMENT INVENTORY OF SOURCES GENERATING ACOUSTIC NOISE AND VIBRATION
E. LOW FREQUENCY NOISE PREDICTIONS (MANAGEMENT PLAN 205M01)
F. LONG DURATION ZERO-G NOISE EXPOSURE LIMITS (MANAGEMENT PLAN 205M03)

G. LOW FREQUENCY NOISE DATA FROM SHUTTLE BEFORE AND DURING ORBIT

CRITICAL ASSUMPTIONS:

(01) A low-frequency acoustic test facility is available to appraise passive and active techniques to transform or modify acoustic energy.

(02) Space shuttle availability for low-frequency noise measurements on the ground and in orbit.

(03) Availability of Space Station-type equipment to determine low frequency radiated spectra.

(04) The proposed study will assume a normal atmosphere within the Space Station

SPECIAL REMARKS:

(01) None

REFERENCES:

(01) Hill, R. E., "Space Shuttle Orbiter Crew Compartment Acoustic Noise-Environments and Control Considerations", Rockwell International Space Transportation Systems Division, ASA 108th Meeting (Paper Y2), October 10, 1984

(02) National Aeronautics and Space Administration, "Vibroacoustic Habitability of Space Stations" (by D. G. Stephens), Langley Research Center, Hampton, VA Aug. 30, 1983

NUMBER	TITLE	DATE
205M02	LOW FREQUENCY NOISE CONTROL	6-26-85

STUDY TASKS:

(01) Review Literature - Review literature to determine the methods and effectiveness of low frequency noise controls in current use.

(02) Establish Low Frequency Noise Characteristics - A typical Space Station module shall be identified to estimate the low frequency reverberation room constant. Typical interior material and construction shall be assumed. Measure or estimate by extrapolation, the low frequency absorption coefficients. Calculate the low frequency noise differences between atmospheric conditions and outer space conditions. Determine the amount of acoustic absorption or negation necessary to reduce the room constant at low frequencies.

(03) Develop Low Frequency Test Methods - Develop facilities and methods to test materials at the low frequency end of the spectrum (1Hz to 100Hz) to determine acoustic absorption coefficients and transmission loss and measure low frequency acoustic power radiated by equipment noise sources.

(04) Conduct Liaison With SSP Design - Conduct periodic liaison and coordination with the SSP Design group to provide updated information affecting the analytical and experimental studies.

(05) Perform Experimental Study - Test interior materials for absorption coefficient and transmission loss at low frequencies. Measure low frequency acoustic radiation for Space Station generic equipment. Test passive and active (anti-noise) methods for reducing Space Station reverberent levels. Low frequency noise measurements shall be conducted aboard the Space Shuttle before and during orbiting condition.

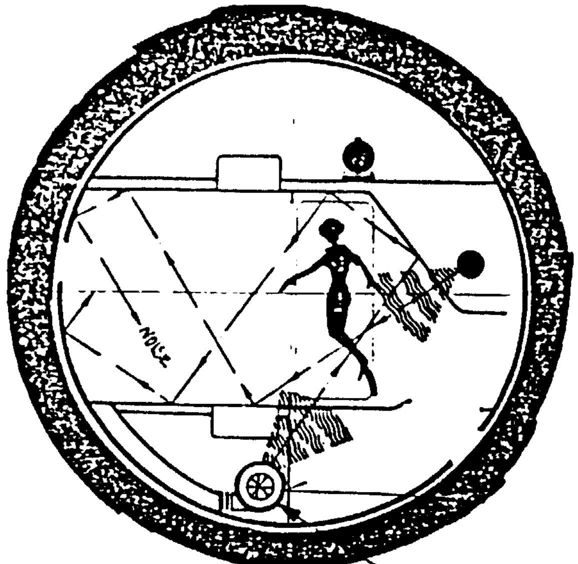
(06) Develop Design Specifications - Develop Space Station module design and procurement specifications which will assure satisfactory room reverberation characteristics and low-level equipment noise generation at the low frequencies.

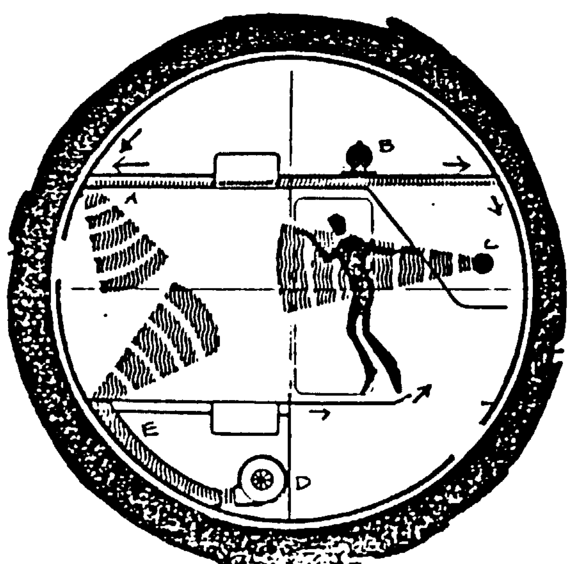
SPECIAL STUDY NEEDS:

TASK(S)	NEED
3	Acoustic Test Facility
3,4	Acoustic and Vibration Measurement Equipment
5	Shuttle Orbiter

SPECIAL SKILLS:

TASK(S)	SKILL





Contributing Factors

- placement/choice of equipment
- room/space design layout
- low absorption coefficient of structural materials at low frequency
- room air volume & structural resonances

Problem Resoltuion

- identify noise sources
- determine noise spectra levels
- recognize noise to listener paths

Noise Reduction

- eliminate acoustic standing waves in module
- active attenuators ⟶ anti-noise
- resonant sound accessories (tuned to frequency)
- fine balancing of rotating machinery
- low friction bearing surfaces
- vibration absorbing equipment mounts
- use of acoustic enclosures

Noise Proliferation

⟶ vibration path
- structure vibrates, radiates sound
- vibration source, motor pump
- directly radiating source
- fan noise source
- airduct distributes noise

FIGURE 1 (Management Plan 205M02)
LOW FREQUENCY NOISE CONTROL

2	Computer Programming
1,2,3,4,5,6	Acoustics Specialist
3,5	Acoustics Test Engineer

PERFORMING ORGANIZATION:

(01) Managing: NASA - LaRC

(02) Doing: Aerospace Firms, WP 01 (Prime)
Acoustic Test Laboratories (Sub)

STUDY PRODUCTS:

01) Low frequency noise control guidelines for the methods and techniques available to control noise at the source and the absorption or negating of acoustic energy released into the air volume.

PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS:

SUBELEMENT NO. & TITLE	Undefined Rqmt #
20501 Noise Control	-03d

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
205M02	LOW FREQUENCY NOISE CONTROL	6-26-85

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                                          1985        |     1986                                  |
                                  CALENDAR|O--N--D--|J--F--M--A--M--J--J--A--S--|
                                    FISCAL|FY 86                                                  |
                                     MONTH|1   2   3    4   5   6   7   8   9   10  11  12 |
                                  PHASE B|                                                        |
                                         C|                                                        |
STUDY  TASKS                              |                                                        |
Assuming Nov. 86 for SDR                  |                                                        |
                                          |G                                                       |
1. Review Literature                      |----                                                    |
                                          |(2 m/m)                                                 |
                                          |  A                                                     |
                                          |  B                                                     |
                                          |  C                                                     |
2. Establish Low Frequency Noise          |  D--------------                                       |
   Characteristics                        |      (4 m/m)                                           |
                                          |  E                                                     |
3. Develop Low Frequency Test Methods|  F--------------                                       |
                                          |      (4 m/m)                                           |
4. Conduct Liaison With SSP Design        |-----------------------------------------               |
                                          |             (2 m/m)                                    |
5. Perform Experimental Study             |          ------------------------------                |
                                          |                 (10 m/m)                               |
6. Develop Design Specifications          |                                         --------       |
                                          |                                          (2 m/m)       |
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REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
205M02	LOW FREQUENCY NOISE CONTROL	6-26-85

SUMMARY SCHEDULE/COST FACTORS

STUDY SPAN: OCT 85-SEP 86 CM = 12

CATEGORY	FACTOR/MM(CM)*	COST $
LABOR		
- NASA Project Mgmt		
- Study Mgmt	4.0 mm	
- Study Tasks		
- Analyst, Eng'g	13.0 mm	
- Special Skills:		
- Test Eng'g.	7.0 mm	
SPECIAL FACILITIES		
- Low Frequency Test Facility	3 cm	
- Full Scale Vacuum Chamber	1 cm	
- Space Shuttle	1 cm	
TRAVEL		
- Coordination w/NASA, SSP Design		15 K
MATERIALS		
- Full Scale Space Station Module Mockup for Vacuum Chamber		75 K
TEST PROGRAM		
- Test Materials and Generic Equipment		10 K
OTHER (List)		

* MM = Manmonths; CM = Calendar Months

REPORT FORMAT 13 MANAGEMENT PLAN OVERVIEW

NUMBER	TITLE	DATE
205M03	LONG DURATION 0-G NOISE EXPOSURE LIMITS	07-17-85

ISSUE #	TITLE	NEED DATE
2050201	LONG DURATION 0-G NOISE EXPOSURE LIMITS	OCT 86

OBJECTIVES:

(01) To develop standards governing long-term human exposure to acoustic noise in a Space Station (0-g) environment.

BACKGROUND:

The living and working conditions which will prevail in a Space Station make it necessary to re-evaluate the physiological and psychological effects of long duration noise on humans. Soviet space station experience has indicated that weightlessness, isolation and continuous monotony play an important role in the determination of noise effects, i.e. mental health, work capacity and fatigue. On both Skylab and Shuttle there have been reported sleep interference, communication interference, distraction and annoyance. Similar complaints were recorded on other U.S. programs like the Ben Franklin submersible, Tektite and the McDonnell Douglas Simulator. Current earth-based criteria do not take into consideration the unique conditions aboard space craft and hence will need to be re-formulated.

In addition, to audible noise criteria there is also a need to evaluate the effects of very low frequency noise on man over a long period of time. These effects are not well understood, even under earth conditions, and there appears to be conflicting conclusions in the literature about them. The possibility exists, however, that low frequency sound can have adverse effects, such as nausea, fatigue, annoyance and loss of proficiency. Some safeguards, therefore, should be taken to minimize the likelihood of such adverse effects.

This issue resolution management plan provides a technical approach to providing standards for long term human exposure to acoustic noise in a Space Station environment.

INPUTS:

A. Space Station module size and configuration.

CRITICAL ASSUMPTIONS:

(01) A Space Station module simulator representing the expected module size and configuration will be available or developed for a 90 day noise response test.

(02) Assumes Dec 86 for SDR.

SPECIAL REMARKS:

(01) For the test, the noise levels to which the test subjects will be subjected will reflect the higher levels expected in the Space Station due to non-transmission noise through the outer walls.

(02) References 01, 02 and 03 must be considered during the execution of this study.

REFERENCES:

(01) "Human Response to Vibroacoustic Environments of Space Vehicles," Kelli F. Willshire, NASA-TM 83616

(02) D. L. Johnson, "The Effects of High Level Infrasound", Conference on Low Frequency Noise and Hearing, 7-9 May 1980, Aalborg, Denmark

(03) "Life Sciences Considerations for Long Duration Manned Space Missions", Shiro Furukawa

REPORT FORMAT 14 STUDY PLAN

NUMBER	TITLE	DATE
205M03	LONG DURATION 0-G NOISE EXPOSURE LIMITS	07-17-85

STUDY TASKS:

(01) Conduct Literature Search - Conduct literature search to establish for earth conditions what the long term noise limits would be.

(02) Set Interim Standards - Consult with experts from NASA, industry and academia to define an interim set of standards for Space Station (0-g) conditions.

(03) Devise Noise Test - Devise test which will measure the physiological and psychological response of humans to noise stimuli.

(04) Conduct Long-term Noise Response Test - Conduct a carefully controlled test to determine the physiological and psychological response of human test subjects to various noise stimulii over a 90 day period of time when confined to small spaces representative of the size and configuration of the Space Station. Obtain subjective (reports of annoyance/disturbance) and objective (neuro-endocrine chemical response) evaluation data from test subjects.

(05) Formulate Standards - Formulate noise standards for long term human exposure under space conditions.

SPECIAL STUDY NEEDS:

TASK(S)	NEED
2	Access to noise experts at NASA and elsewhere
4	Model making capability if simulator not available
4	Laboratory services and technicians
4	Availability of test subjects

SPECIAL SKILLS:

TASK(S)	SKILL
3,4	Environmental/Industrial Psychologist

PERFORMING ORGANIZATION:

(01) Managing: NASA Langley Research Center

(02) Doing: WP-01 Aerospace (Contractors)

STUDY PRODUCTS:

Specifications for exposure limits of humans to long duration noise under Space Station conditions.

<u>PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS</u>:

SUBELEMENT NO. & TITLE		Undefined Rqmt #
20502	PHYSIOLOGICAL/PSYCHOLOGICAL EFFECTS	-01h
20503	PHYSIOLOGICAL EFFECTS	-02,-03

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
205M03	LONG DURATION 0-G NOISE EXPOSURE LIMITS	07-17-85

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                                      1985      |   1986
                             CALENDAR|O--N--D--|J--F--M--A--M--J--J--A--S--|
                               FISCAL|FY 86
                                MONTH|1  2  3   4  5  6  7  8  9  10 11 12 |
                              PHASE B|
                                    C|
STUDY  TASKS
Assuming Dec. 86 for SDR             |
                                     |
1. Conduct Literature Search         |------
                                     |(2 mm)
2. Set Interim Standards             |   -------
                                     |    (2 mm)
3. Devise Noise Test                 |A----------------
                                     |      (4 mm)
4. Long Term Noise/Response Test     |-------------------
                                     |      (8 mm)
5. Formulate Standards               |                       ---------
                                     |                        (3 mm)
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REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
205M03	LONG DURATION 0-G NOISE EXPOSURE LIMITS	07-17-85

SUMMARY SCHEDULE/COST FACTORS

STUDY SPAN: OCT 85-SEP 86 CM = 12

CATEGORY	FACTOR/MM(CM)*	COST $
LABOR		
- NASA Project Mgmt		
- Study Mgmt	4 mm	
- Study Tasks		
- Analyst, Eng'g	7 mm	
- Special Skills:		
-Industrial Psychologist	8 mm	
SPECIAL FACILITIES		
- Mock-up or Representative Layout Model	3 cm	
TRAVEL		
- Meeting with NASA, others		5 K
MATERIALS		
- Model/Mock-up Fabrication		10 K
TEST PROGRAM		
- Test Subjects for 3 month Noise Test		12 K
OTHER (List)		

* MM = Manmonths; CM = Calendar Months

REPORT FORMAT 13 MANAGEMENT PLAN OVERVIEW

NUMBER	TITLE	DATE
207M01	ZERO-G SPORTS AND GAMES	07-19-85

ISSUE #	TITLE	NEED DATE
2070104	ZERO-G SPORTS AND GAMES	MAY 88

OBJECTIVES:

(01) Provide an alternative to single person exercises as the predominant means of cardiovascular/musculoskeletal conditioning through the development of one or more sports/games in which two or more crewmembers can participate, and which ideally require a substantial amount of aerobic exercise, muscle strength and endurance,neuromuscular coordination, and loading of the musculoskeletal system.

(02) Develop the equipment, facilities, and procedures to enable the sport(s) to be played on the Space Station.

(03) Provide a means of monitoring the crewmembers during and/or after the sport/game is played to evaluate its efficacy as a physiological countermeasure.

BACKGROUND:

Both U.S. and Soviet investigators have observed physiological adaptive changes which occur in both short-and long-duration space missions (1,2,3,4). These changes include a) cardiovascular deconditioning, manifested by postflight orthostatic intolerance, decreased cardiac output, and reduced exercise capacity; b) muscle atrophy, manifested by weakness and poor gravitational tolerance postflight; and c) bone mineral loss, manifested by increased calcium excretion during flight and resulting in increased potential for bone fracture postflight. Both cardiovascular and musculoskeletal deconditioning may also impair the ability of a spaceflight-adapted crewmember to function and perform adequately during critical phases of reentry and landing.

Since the absence of gravity is the underlying factor which causes the changes leading to both cardiovascular and musculoskeletal deconditioning, efforts to prevent or reduce the deconditioning have generally emphasized techniques which provide weight forces on the body to simulate earth-type 1-G stresses. In the absence of artificial gravity, both the U.S. and Soviet space programs have used various forms of exercise as the centerpiece of their countermeasures regimen (frequently combined with periodic application of lower body negative pressure).

A variety of exercises and exercise devices have been utilized in space, and most of these have been reported to counteract some of the deleterious effects of the microgravity exposure. The development of exercise as a countermeasure has involved a balancing of efficacy, crew time required, size of equipment, and ease of performance.

Different types of exercise have been assessed to provide different amounts of protection and efficacy (5). Isotonic and isokinetic exercises work well in preventing mass and strength loss in the muscle groups exercised. "Walking" under the forces applied by bungee cords appears to reverse muscle atrophy and improve coordination, while just standing under the same forces should provide some protection against loss of bone mineral constituents. Endurance exercises such as pedaling a bicycle ergometer or "running" on a treadmill prevent reduction in heart size and mass, and decreases in respiratory capacity, and probably increase circulatory blood volume.

Because of the above observations, it has been concluded (5) that a combination of exercise techniques, in the presence of a 1-G equivalent force, would be the most effective way to reduce muscle, joint, and bone atrophy, minimize reduction in heart size/mass; and maintain exercise capacity. The problem remains, however, given the specification of combined exercise techniques, what is the optimum amount (duration and frequency) of exercise for a given individual?

The exercise regimens prescribed for both U.S. and Soviet space mission have required longer and more frequent exercise sessions as the length of the mission increased. In Skylab, 0.5, 1, and 1.5 hours of bicycle ergometry were used on the 28, 56, and 84 day missions, respectively (2). During Salyut 6, the Soviet cosmonauts spent three hours per day exercising (6). Current U.S. Space Station planning guidelines are reserving one hour per day for exercise in ninety-day missions (7), with the caveat of unspecified increases in the daily exercise prescription later in the mission, since individual needs may vary.

It is clear from this discussion that the time dedicated to physiological countermeasures will have a substantial impact on human productivity on Space Station. Opinions from Shuttle crewmembers solicited in conjunction with preparation of the Crew Interface Panel Space Station Habitability Requirements Document (8) indicated that some felt that one or more hours per day of a single-person exercise such as pedaling a bicycle ergometer or running on a treadmill would soon grow extremely tedious and boring, and become a negative rather than positive psychological factor. Based on the time requirement and the physiological and psychological considerations, it may be concluded that an activity for two or more persons which provides a comparable amount of aerobic exercise, as well as muscle strength, endurance, and coordination challenges, and skeletal loading, which is also fun and does not quickly become as routine/boring as one-person bicycle/treadmill exercise, would be a valuable asset to human productivity. With the capability to engage in one or more such sports/games, physiological conditioning could take place, for some crewmembers at least, during their recreation time.

This issue resolution management plan provides a technical approach for developing one or more zero-G sports as an alternative to single person exercise countermeasures. It also addresses the development of equipment, facilities, and procedures for the implementation of these sports on the Space Station.

<u>INPUTS</u>:

A. PHYSIOLOGICAL COUNTERMEASURES STDS (Issue 2070101)
B. EXERCISE TIME RQMTS (Issue 2070102)
C. ZERO-G AEROBIC EXERCISES (Issue 2070103)
D. ROUTINE HEALTH MONITORING REQMTS (Issue 2070203)
E. INDIVIDUAL RECREATIONAL PREFERENCES (Issue 2090101)
F. 0-G REC ACTIVITIES, EQUIPMENT & MATLS (Issue 2090102)
G. FACILITY FOR GROUP RECREATION (Issue 2090201)
H. RECREATION OBJECTIVES (Issue 2090501)
I. Crew characterisitcs
J. Crew activities in specific locations
K. Work and living space configurations

<u>CRITICAL ASSUMPTIONS</u>:

(01) There will not be any provision for Space Station-wide or whole module-level artificial-gravity at IOC.

(02) There will not be any additional volume for allocation to a dedicated sports facility at IOC, i.e., a general purpose area or HMF/HRF exercise area must be reconfigured for the sport.

<u>SPECIAL REMARKS</u>:

(01) Judgement concerning what types of sports and games are challenging or recreational are highly subjective, therefore selection of one or more concepts to develop will require close coordination with the candiate crew population. Individual preferences, variations in activities which are feasible or desired with different crew sizes/mix and international crews, and determination of those activities most conducive to improving mental health and reducing boredom, will be addressed in the issue resolution plans for #2090101, Individual Recreational Preferences and #2090501, Recreation Objectives.

(02) The focus of this plan is to develop an activity which will serve as a cardiovascular/musculoskeletal countermeasure. Therefore, the primary consideration is given to the efficacy of the sport as a countermeasure rather than its potential for recreation.

(03) The physiological monitoring which would be necessary periodically throughout a mission to assess the efficacy of the sport as a countermeasure is addressed in the issue resolution plan for 2070203, Routine Health Monitoring Requirements.

<u>REFERENCES</u>:

(01) A. E. Nicogossian and J. F. Parker, eds., Space Physiology and Medicine, NASA SP-447, NASA HQ, Washington, D.C., 1982.

(02) R. S. Johnston and L. F. Dietlein, eds., Biomedical Results from SKYLAB, NASA SP-377, NASA HQ, Washington, D.C. 1977.

(03) E. I. Vorobyov, O. G. Gazenko, A.M. Genin, and A. D. Egorov; "Medical Results of Salyut-6 Manned Space Flights." Aviation, Space and Environmental Medicine 54(12); S31-S39, 1983.

(04) M. Calvin and O. G. Gazenko, eds., Foundations of Space Biology and Medicine, NASA SP-374, NASA HQ, Washington, D.C. 1975.

(05) W. Thornton, "Rationale for Exercise in Spaceflight," in Spaceflight Deconditioning and Physicial Fitness Conference Proceedings, National Aeronautic and Space Administration 8-10 January 1981.

(06) J. P. Kerwin, "History of Exercise in Spaceflight" in Spaceflight Deconditioning and Physical Fitness Conference Proceedings, NASA, 8-10 January 1981.

(07) NASA Solicitation #9-BF-10-4-01P, "Space Station Definition & Preliminary Design, Request for Proposal," September 1984.

(08) Crew Interface Panel Space Station Habitability Requirements Document, JSC-19517, NASA JSC, December 1983.

REPORT FORMAT 14 STUDY PLAN

NUMBER	TITLE	DATE
207M01	ZERO-G SPORTS AND GAMES	07-19-85

STUDY TASKS:

(01) Conduct a literature review to identify all physical exercises used by U.S. and Soviet space crews as countermeasures. Identify the time and equipment required, crew acceptance, and efficacy as countermeasures.

(02) Survey those new exercises and equipments developed under #2070103 and any recent flight data to assess their efficacy as countermeasures.

(03) Survey the results of #2090101 to determine a profile of sports preferences of the current candidate crew population.

(04) Review current Space Station design efforts to establish candidate locations, volumes, timelines, and other resource constraints within which the sports activity must fit.

(05) Identify/develop concepts for sports activities which
- a) enable two or more players to participate;
- b) require, on the average, amounts of aerobic exercise comparable to the best single person exercises;.
- c) may require strength, endurance, coordination, and skill;
- d) employs resources, including crewtime, which conceivably fit within the station's resources.

The concepts developed may be zero-g adaptations/simulations of known one-g sports, or they may be new sports unique to the zero-g environment.

(06) Summarize resource requirements, development costs, and other factors such as countermeasure efficacy, safety, ease of use, and crew appeal/acceptance, and select one or more concepts for further development (or NO-GO decision; a good zero-g sport may need to be developed in zero-g).

(07) Develop full scale mockup of the sports equipment/sports facility to verify dimensions and requirements for recreation facility (or other facility) convertibility. Develop any unique visual or motion simulations and software needed to support these simulations as part of the sports facility.

(08) Plan an appropriate verification test

- a) If the sport requires repeated actions, each taking a few seconds or less, e.g. swinging a racquet, throwing/catching a ball, shooting a basket, then KC-135 parabolic flight may be appropriate.
- b) If the sport requires an endurance task, e.g., running, "skiing", climbing, then a Shuttle experiment, or possibly Neutral Buoyancy Simulator test, may be appropriate.

c) If the sport requires a combination of a) one b), then a complete ground-based verification, or even a Shuttle experiment verification may not be feasible. Ultimately the entire sport must be verified (and modified if necessary) in the Space Station.

(09) Develop test hardware and conduct verification test; modify equipment procedures as indicated by results, and reverify.

(10) Formulate flight hardware design specifications, interface design specifications, and detailed procedures, for integration with Space Station's detailed design phase.

SPECIAL STUDY NEEDS:

TASK(S)	NEED
2,3	Access to NASA countermeasures experts and the candidate crew population
4	Availability of Space Station configuration data and crew timeline data
7	Model-making capability
7	Access to full-scale mockups
7,9	Prototype hardware development capability
7	Dynamic simulation development and software support
8,9	KC-135 flights
8,9	Neutral buoyancy facility
8,9	Shuttle flights

SPECIAL SKILLS:

TASK(S)	SKILL
1,2,5	Space Medicine/Physiological Countermeasures Specialist
2,3,5	Exercise Physiologist/Sports Medicine Specialist
7	Crew Systems Design/Interior Design Specialist
7,8,9	Dynamic Simulation Engineers, Systems Analysts, and Programmers

PERFORMING ORGANIZATION:

(01) Managing: NASA JSC (Manned Systems Division with Life Sciences Support)

(02) Doing: Aerospace Firms (prime)

Space medicine and exercise physiology consultants (sub)

STUDY PRODUCTS:

(01) Assessment of feasibility of various concepts of zero-g sports based on development cost, Space Station design and operations impact, and physiological countermeasure efficacy.

(02) Detailed design specifications for one or more zero-g sports, including specifications of equipment/facilities to accommodate the sport, and space station interface specifications.

PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS:

SUBELEMENT NO. & TITLE	Undefined Rqmt #
20701 PHYSIOLOGICAL CONDITIONING/COUNTERMEASURES	-05

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
207M01	ZERO-G SPORTS AND GAMES	07-19-85

	1985			1986								
CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S
FISCAL	FY 86											
MONTH	1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												

STUDY TASKS	Schedule
1. Conduct Literature Review	---- 2 mm
2. Perform Survey of New/Proposed Zero-G Exercise Devices	C ---- 2 mm
3. Review Survey of Sports Preferences	E -------- 2 mm
4. Review and Analyze Space Station Design Data	F,G,J,K ---------- 5 mm
5. Develop Sports Concepts	--------- 10 mm
6. Analyze Feasibility/ Countermeasure Efficacy & Decide Go/No-Go	A,B,D,H,I ----------- 7 mm

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
207M01	ZERO-G SPORTS AND GAMES	07-19-85

	1986			1987								
CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S
FISCAL	FY 87											
MONTH	1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												
STUDY TASKS												
7. Develop Mock-up & Simulation	----	----	----	----	----	----						
				14 mm								
8. Plan Verification Test							----	----	----			
							7 mm					
9. Develop Test Hardware & Conduct Test										----	----	----
										8 mm		

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
207M01	ZERO-G SPORTS AND GAMES	07-19-85

	1987			1988								
CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S
FISCAL	FY 88											
MONTH	1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												
STUDY TASKS												
9. Develop Test Hardware & Conduct Test	40 mm (months 1–7)											
10. Formulate Flight Hardware Design Specifications						4 mm (months 6–7)						

REPORT FORMAT 15 — SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
207M01	ZERO-G SPORTS AND GAMES	07-19-85

SUMMARY SCHEDULE/COST FACTORS

STUDY SPAN: OCT 85-MAY 88 CM = 31

CATEGORY	FACTOR/MM(CM)*	COST $
LABOR		
- NASA Project Mgmt		
- Study Mgmt	18	
- Study Tasks		
- Analyst, Eng'g	35	
- Special Skills:		
Space Medicine/CM Spec	10	
Exercise Physiologist/Sports Med Spec	10	
Crew Systems/Int. Des. Spec.	16	
Simulation/Software Spec.	22	
TASK TOTAL	111 MM	
SPECIAL FACILITIES		
KC-135	2 CM	
Neutral Buoyancy Facility	2 CM	
Shuttle Flight	.25 CM	
TRAVEL		45 K
Coordination of NASA, Aerospace Firms, and Consultants; Crew Surveys		
MATERIALS		
Mockup Fabrication Materials		10 K
Simulation Development Materials		10 K
Test Hardware Materials		50 K
TEST PROGRAM		1000 + K
Test Hardware		
KC-135 Flight Time		
Neutral Buoyancy Facility Costs		
Shuttle Flight Costs		
OTHER (List)		

* MM = Manmonths; CM = Calendar Months

REPORT FORMAT 13 MANAGEMENT PLAN OVERVIEW

NUMBER	TITLE	DATE
207M02	ANIMAL PAYLOAD BIOISOLATION	07-19-85

ISSUE #	TITLE	NEED DATE
2070301	ANIMAL PAYLOAD BIOISOLATION	JUL 86

OBJECTIVES:

(01) Establish guidelines for what pathogens (associated with non-human payloads) are not allowed to be carried up to the Space Station.

(02) Develop a plan for screening research animals and other non-human biological specimens to be flown on the Space Station.

(03) Develop the design and procedural concepts for providing microbiological isolation of non-human biological specimens from the rest of the Space Station, including inflight and ground operations.

BACKGROUND:

A substantial amount of Life Sciences payload resources planned for Space Station are dedicated to experiments with non-human biological specimens, most of these specimens being research animals such as rodents and primates (1,2,3). To accommodate these Life Sciences requirements, various concepts and configurations have been developed as baseline references for Space Station definition and preliminary design activity (4,5), and various guidelines/requirements have been established in connection with bioisolation of animal payloads to ensure crew health and safety (1,2,6).

The research animal holding facility (RAHF) developed for use in Spacelab has an environmental control system which provides air circulation, temperature and humidity control, and microbiological, particulate, and odor filtration of the air effluent from the animal cages. However, the RAHF depends on the Shuttle's ECLSS for its oxygen supply and carbon dioxide removal. In addition, experiments which call for manipulation of the specimens require a brief period of exposure of the animals to the Spacelab ambient atmosphere while the cage module is transferred to the General Purpose Workstation. Recent flight experience (Spacelab 3) has demonstrated several problems in the RAHF design resulting in escape of food and fecal particulates from both the primate and rat cages, primarily during servicing of food bars and waste trays (8). The leakage of material from the cages was attributed to inadequate seal design and higher than expected vigor of monkeys, who kicked the material through the airflow of their zero-g cages into the Spacelab (9).

A recent study was performed which described the problem and identified various alternative solutions(10). However, the problem remains for Space Station planners and designers to select an approach for bioisolation of the animal/plant research facility, and equipment

and procedures which permit crew members to enter the facility, manipulate the specimen, and exit the facility, without carrying contamination with them. Considerations to be studied include:

a) Module Design/Architecture - barriers within module (isolation between Human Research Facility (HRF) and Animal/Plant Research Facility (APRF), airlock between modules (isolation at module level), air showers, water showers, separate ECLSS vs Filters, UV light, laminar airflow.

b) RAHF Design - isolation at cage level with negative pressure air flow, isolation at RAHF level

c) ECLSS Design - filter material selection, sizing, airflows

d) Workstation Design - laminar air flow, UV light, animal transporter design

e) Flight Procedures - means of cleaning, servicing, and resupplying cages, methods for hand/whole-body washing, overall housekeeping in lab module, means of getting animals to and from workstation

f) Ground Procedures - Animal screening and selection criteria, preflight isolation requirements, ground transporation and loading of animals.

Concern for biocompatibility of research animals and crew in a sealed environment (unlike ground laboraties where animals are housed in a separate facility) was raised within NASA in 1977 during an early Shuttle Mission Simulation (SMD-III). Specific pathogen lists were developed for both flight rodents and non-human primates by JSC medical personnel. Procurment of Specific Pathogen Free (SPF) animals and maintaining the SPF condition has been difficult. On STS-41B, rats assumed to be SPF were flown but found postflight to be carrying an undesirable pathogen. The source was unknown - possibly the food supply or an unsterile cage. However, the animals were isolated from the crew in that the cage was not opened and the air effluent was filtered before re-entering the Spacelab. As a result, screening and maintenance of SPF animals has received increasing surveillance by the astronaut corps. In addition, medical research is continuing to uncover substances that are carcinogens which were previously assumed to be harmless. Therefore, NASA is devoting significant efforts to assure astronaut health under all research conditions.

<u>INPUTS</u>:

A. Laboratory Module Configuration/Design Concepts
B. Space Station ECLSS Configuration/Design Concepts
C. Life Sciences Baseline Reference Mission
D. NIH Revised Guidelines on Microbiological Environmental Safety Criteria for Space
E. ATMOSPHERE SPECIFICATION (Issue #2010101)
F. MICROBIAL LOAD MODEL (Issue #2010302)
G. CONTAMINATION UNITS LIMITS (Issue #2010303)
H. Spacelab RAHF performance data
I. Life Sciences Research Facility Bioisolation Study (Ref. 10)

CRITICAL ASSUMPTIONS:

(01) The Animal/Plant Research Facility (APRF) and the Human Research Facility, as well as an Operations & Control area for other (e.g. astrophysics) payloads, will occupy the same module at IOC.

(02) The APRF will have, as a minimum, a separate ECLSS which is independent of Space Station ECLSS services. In addition, there may be lower levels of bioisolation required/desired.

(03) Life Sciences non-human experiments will require specimen manipulation at a location (workstation) removed from the cage enclosure, e.g. surgical procedures.

SPECIAL REMARKS:

(01) Guidelines concerning pathogens which are not allowed to be carried up by crew members, for preflight health stabilization programs, and for bioisolation requirements, if any, at crew rotation, will be addressed separately in the management plans for #2070302, Crew-Rotation Microbiological Requirements, and #2070303, International Crew Preflight Health Requirements.

(02) Guidelines concerning animal-carried pathogens which are not allowed to be carried up in the Shuttle currently exist, and were amended prior to Spacelab 3 to include Herpes S virus. An effort is currently underway at N.I.H. to establish revised guidelines for microbiological environmental safety criteria for space. In the absence of these revised guidelines, in-house studies at NASA indicate that the most practical solution will probably involve the use of gnotobiotic animals for future Spacelab missions. This will permit the controlled introduction of acceptable microbiological profiles to research specimens.

(03) In addition to the potential problems associated with cross-contamination from animals to humans, there are a similar set of problems associated with cross-contamination from humans to animals. This issue resolution plan acknowledges the concern from the payload standpoint, but does not address the "reverse contamination" issue.

(04) A bioisolation verification test should be performed, however, this should only be done with prototype flight hardware of the cages, cage transporters, RAHFs, APRF compartment, and APRF-Lab Module interface. Such testing will be needed to verify bioisolation effectiveness, to demonstrate/modify procedures, and to provide for crew training. However, such testing is considered part of flight hardware development, and is considered beyond the scope of this issue resolution plan.

REFERENCES:

(01) Philip C. Johnson & John A. Mason, eds., Medical Operations and Life Sciences Activities on Space Station", NASA Technical Memorandum 58248, NASA JSC, October 1982.

(02) "Life Sciences Considerations for Space Stations" Life Sciences Division, NASA Headquarters, September 14, 1982.

(03) "Life Science Requirements for Space Stations. Consolidations of Requirements Identified in Previous Space Station Studies", 1960-1980 McDonnell Douglas Technical Services Co., Inc. March 1981.

(04) "Space Station References Configuration Description", NASA-JSC (JSC-19989), August 1984.

(05) "Space Station Mission Data Books and Customer Accommodation Plans for Early Missions", Volume III of the Space Station Customer Accommodation and Planning Study (NAS 8-35611-1), McDonnell Douglas Astronautics Company, 1984.

(06) NASA Solicitation #9-BF-10-4-01P, "Space Station Definition & Preliminary Design, Request for Proposal," September 1984.

(07) T. M. Olcott and C.E, Rudiger, "Lockheed Involvement in Shuttle Life Sciences Flight Experiments," Advanced Systems Division, Lockheed Missile & Space Co., Sunnyvale CA, 1984.

(08) T. O'Toole, "Particles Fill Air in Spacelab," The Washington Post, May 1, 1985.

(09) Aviation Week and Space Technology, May 13, 1985 p.19.

(10) Life Sciences Research Facility Bioisolation Study, Lockheed Missiles and Space Company Report under NASA/MSFC Contract No. NAS 8-35472, April 1985.

(11) Personal Communication with Dr. Lynn Griffiths, MATSCO, regarding current work of Dr. Emmett Barkley, Director of the Office of Research Safety, N.I.H., June 1984.

REPORT FORMAT 14 STUDY PLAN

NUMBER	TITLE	DATE
207M02	ANIMAL PAYLOAD BIOISOLATION	07-19-85

STUDY TASKS:

(01) Review N.I.H. revised guidelines on microbiological environmental safety criteria for space and other relevant microbiology/immunology literature.

(02) Review data from current Space Station Laboratory Module and ECLSS design efforts, including current Life Sciences Baseline Reference Mission.

(03) Review current (Spacelab) RAHF design, RAHF flight experience reports, and proposals for modification of current RAHF.

(04) Review Lockheed report on alternative approaches to animal bioisolation.

(05) Develop comprehensive listing of alternative approaches to bioisolation, including those from task(4) as well as new concepts. Consider several architectural levels of bioisolation, e.g. cage, RAHF, APRF, Lab Module; and consider at least two atmospheric specification levels of bioisolation (e.g. current NASA criteria, NIH criteria).

(06) Eliminate those approaches, if any, which are clearly incompatible with basic Space Station Program requirements. Using remaining list, perform a series of trade-off studies among the various alternatives, using a structured evaluation approach, such as the Kepner-Trago Approach (KTA); the trades should consider the following evaluation factors:

a) Design Impact
-Weight
-Power
-Volume
-Complexity
-Technology Availability
-Capability to Accommodate Growth

b) Operations Impact
-Crew Time
-Ground Support Time
-Procedural Complexity

c) Cost
-Development Cost
-Life Cycle Cost

d) Other Factors
-Bioisolation Effectiveness
-Safety
-Reliability
-Maintainability
-User Acceptability (payload office, P.I's)

Appropriate weighting factors should be developed in coordination with NASA Space Sation Program managers. Evaluation of some factors will require consultation with flight-experienced crew members, microbiologists, and other experts. Evaluation of procedures associated with each option may require access to full scale mockups.

(07) Select the concept which best fits overall program needs, and develop detailed design specification and procedures descriptions.

SPECIAL STUDY NEEDS:

TASK(S)	NEED
1	Availability of N.I.H. environmental criteria, NASA/JSC environmental criteria, and access to the experts who developed these criteria.
2	Availability of Space Station configuration data, ECLSS performance data.
3	Availability of current RAHF design data and current flight experience data
6	Access to full-scale mockups

SPECIAL SKILLS:

TASK(S)	SKILL
1,3,4,6,7	Microbiologist
3,4,6,7	Veterinarian/Animal Physiologist (P.I.)
1,2,3,4,5,6,7	Environmental Control System Specialist
2,3,4	Human Factors Engineer
2,3,4,6	Crew Systems Design Specialist

PERFORMING ORGANIZATION:

(01) Managing: NASA/ARC Life Sciences

(02) Doing: Aerospace Firms (prime)
Universities (sub)
Consultants (Microbiology, Veterinary Medicine, Human Factors) (sub)

STUDY PRODUCTS:

Detailed design specifications for:

(01) All hardware and procedures which support non-human biological specimens and provide for the microbiological isolation from the rest of the Space Station.

- -Cages
- -Animal Holding Facilities
- -Workstation
- -APRF-HRF Barrier & Entrance
- -Housekeeping Hardware
- -Housekeeping/Cleaning Procedures
- -Crew Entrance/Exit Procedures
- -Specimen Transfer/Manipulation Procedures

(02) All interfaces of the above hardware/procedures with the rest of Space Station.

PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS:

SUBELEMENT NO. & TITLE	Undefined Rqmt #
20703 DISEASE PREVENTION	-07

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
207M02	ANIMAL PAYLOAD BIOISOLATION	07-19-85

	1984			1985								
CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S
FISCAL	FY 85											
MONTH	1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												
STUDY TASKS												
1. Review NIH Revised Guidelines										D ----	2 mm	----
2. Review Space Station Lab Module, ECLSS, Life Sciences BRM Data										A,B,C ----	3 mm	----
3. Review RAHF Data										H ----	3 mm	----

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER: 207M02

TITLE: ANIMAL PAYLOAD BIOISOLATION

DATE: 07-19-85

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                                        1985       |   1986                                    |
                               CALENDAR|O--N--D--|J--F--M--A--M--J--J--A--S--|
                                 FISCAL|FY 86                                               |
                                  MONTH|1  2  3    4  5  6  7  8  9  10 11 12 |
                                PHASE B|                                                    |
                                      C|                                                    |
STUDY  TASKS                           |                                                    |
2.  Review Space Station LM, ECLSS &   |                                                    |
    LS/BRM Data                        |--                                                  |
                                       |1 mm                                                |
                                       |                                                    |
3.  Review RAHF Data                   |--                                                  |
                                       |1 mm                                                |
                                       |                                                    |
4.  Review LMSC Report                 |I ------                                            |
                                       |   2 mm                                             |
                                       |                                                    |
5.  Define Alternatives & Trade        |    ----------                                      |
    Studies                            |      6 mm                                          |
                                       |                                                    |
6.  Perform Trade & Select Concept     |E,F,G  ------------------------                     |
                                       |                    14 mm                           |
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REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
207M02	ANIMAL PAYLOAD BIOISOLATION	07-19-85

SUMMARY SCHEDULE/COST FACTORS

	STUDY SPAN: JUL 85-JUL 86 CM = 12	
CATEGORY	FACTOR/MM(CM)*	COST $
LABOR		
- NASA Project Mgmt		
- Study Mgmt	4 MM	
- Study Tasks		
- Analyst, Eng'g	6 MM	
- Special Skills:		
Microbiologist	6 MM	
Vet/Animal Physiologist	4 MM	
ECLSS Spec	6 MM	
Human Factors Spec	5 MM	
Crew System Design Spec	5 MM	

SPECIAL FACILITIES

High Fidelity Lab Module Simulation with Prototype Flight Hdwe (cost assumed part of flight hardware development; availability of simulator and prototype hardware will be beyond the end of this study)

TRAVEL

Coordination among NASA, NIH Aerospace Firms, Consultants 20K

MATERIALS

Prototype flight hardware (cost assumed part of flight hardware development)

TEST PROGRAM

Microbiological verification test
(Cost assumed part of flight hardware development, and testing would be performed beyond the end of this study)

OTHER

* MM = Manmonths; CM = Calendar Months

REPORT FORMAT 13 MANAGEMENT PLAN OVERVIEW

NUMBER	TITLE	DATE
207M03	TASK PERFORMANCE ASSESSMENT	6-25-85

ISSUE #	TITLE	NEED DATE
2070401	ZERO-G VISUAL PERFORMANCE CHANGES	Sep 87
2070402	CRITICAL TASK PERFORMANCE ASSESSMENT	Sep 87

OBJECTIVES:

(01) Identify critical tasks required by Space Station payloads and station operations.

(02) Develop appropriate performance measurements for all critical tasks identified.

(03) Develop guidelines for predicting changes in sensorimotor performance as a function of mission duration.

(04) Establish guidelines for application of critical task performance measurements.

BACKGROUND:

A critical task is any task or sequence of tasks which, if not accomplished in accordance with system requirements, will most likely have adverse effects on cost, system reliability, efficiency, effectiveness, or safety(1). Critical task performance is usually part of a single line of flow in the operation or maintenance of a system. Human performance is also considered critical whenever equipment design characteristics demand performance which approaches the limits of, or exceeds, human capabilities. The identification of critical tasks on Space Station must consider both aspects of criticality, i.e., the impact of unsuccessful task accomplishment and the impact of human limitations upon successful/unsuccessful task accomplishment.

The potential for exceeding the limits of human capabilities or for creating mismatches between man and machine can be attributed to the inavailability of sufficient human factors information and human engineering design criteria during the process of system function allocation. This potential for design problems may then be heightened or lessened by secondary factors which include: detailed design of man-machine interfaces, crew stations, equipments, and tools; primary and secondary job requirements; presence of emergency conditions and environmental stressors; diet, exercise and variations in physiological and psychological conditions; and the adequacy of personnel selection and training procedures.

To avoid added costs and schedule delays arising from mission degradation or the necessity to retrofit system function allocation after the system has been designed/fabricated, all human tasks should be allocated and designed with reference to a detailed, multidisciplinary human factors information base. Building on existing

manned spaceflight human factors knowledge (2,3,4,5,6), this base of information should contain categorized knowledge of the environmental effects of the complete mission profile (one-g, multiple-g, zero-g, multiple-g and one-g) upon: 1)task proficiency for a wide variety of representative tasks; 2) bio-functional capabilities; and 3) interrelationships among and between space task proficiency and bio-functional capabilities. The multiple, overlapping bio-functional capabilities of interest would include the primary determinants of space task performance. For example, detailed knowledge of the respective types and levels of visual, vestibular, auditory, tactile, perceptual-motor, cognitive, psychological, physiological and physical functioning is required for decisions involving the utilization of humans in space.

Given the identification of critical tasks and the judicious allocation of all critical tasks between man and machine, there remains a set of tasks that have been judged to be within the mental and physical capabilities of the anticipated Space Station crew population. There also remains several questions about human performance in space during a 90-day mission:

a) How will NASA mission managers know if any individual crewmember is experiencing a degradation in mental or physical capabilities (e.g. visual or auditory performance, sensorimotor performance, fine motor skills, strength, endurance, cognitive ability, memory, etc.) of sufficient magnitude to compromise critical task performance? Results of past space missions have reported changed in several human functions, including visual performance and physical strength and endurance (7,8).

b) How will task performance be measured in order to answer question (a) for each critical task identified? The workload assessment literature documents many techniques for consideration (9).

c) How frequently and when will critical task performance be measured? The measurement itself is subject to error, and could become an encumbrance, a source of friction, or have other adverse effects on human productivity.

The requirement for knowledge concerning the complementary, multidemensional determinants of performance will become more important when personnel less capable and experienced than past, highly qualified astronauts will be selected and trained for tasks on Space Station. Knowledge of these complementary bio-functional determinants of space task proficiency is predicated, in large part, upon multidimensional assessment of task performance.

While time required for task accomplishment is an important summary criterion of performance, this unitary criterion will not support development of a multidisciplinary human factors information base that is sufficient for scientifically allocating system functions, designing man-machine interfaces and life-support systems, selecting personnel and developing training systems for those personnel. Supplementary performance evaluation methodologies and multiple criteria must be employed and developed to reveal information about the underlying, primary determinants of task proficiency.

Identification of these complementary bio-functional determinants of task proficiency for a variety of tasks, when coupled with knowledge about the effects of mission profiles and protective ensembles upon both the determinants and task proficiency, will provide much of the multidisciplinary human factors information base required to insure that man's task requirements are consistent with his multidimensional capabilities and limitations. Moreover, this information base will both help limit the number of critical tasks and provide information which is requisite to predicting if individual and collective tasks will exceed man's capabilities in space.

In summary, Manned and Man-tended Space Stations pose even greater challenges than have past space missions for a variety of reasons, including: future tasks are envisioned to be more complex than past tasks; the population of candidate astronauts will be, more heterogeneous and perhaps less familiar with space operations than their predecessors; constraints of time and funding will prohibit the costly and extensive training and cross-training made available to previous astronauts; and only limited information is currently available concerning the interrelationships between space task proficiency and the underlying bio-functional determinants of task proficiency. These reasons all argue for rapid expansion of the technology base of human performance in space.

This issue resolution management plan provides a technical approach for selecting a methodology and using it to identify and minimize critical tasks on Space Station. The plan also provides procedures for developing performance measures and performance assessment criteria, including identification of the underlying physiological and biochemical determinants/correlates of space task proficiency for a wide variety of tasks. A parallel area of research aimed at identifying changes in vision and sensorimotor performances is also integrated into the overall plan. Finally, the findings of critical task identification, critical task performance assessment, and human performance capabilities changes, are integrated to enable establishment of guidelines for the application of task performance measures.

<u>INPUTS</u>:

A. Principles, procedures, specifications and design criteria for human factors and human engineering.
B. Mission analysis information, including Manned and Man-Tended Space Station functions allocated to man, equipment, software and combinations.
C. Task descriptions and task analysis data.
D. Workload analysis.
E. WORKLOAD ASSESSMENT COMPUTER MODEL (ISSUE 3100201)
F. Space Station system and subsystem designs, drawings and performance requirements.
G. WORKSTATION DESIGN GUIDELINES (ISSUE 4010201).
H. TASK VERIFICATION AT WORKSTATIONS (ISSUE 4010202).
I. Coordination with all 30601,30602,30603 issue resolution plans.
J. Specification of Space Station Training Systems.
K. Man/System Integration Standards, Requirements and Guidelines (Lockheed/Boeing Study Final Report)

CRITICAL ASSUMPTIONS:

(01) The Space Station crew population will be more heterogenous than previous astronaut populations, and will demonstrate more individual variability in inherent task performance capability.

(02) The Space Station Program will provide less extensive training for crewmembers than previous mission training programs. Space Station will depend more heavily on on-the-job training and computer-aided training during the mission.

(03) A full scale, one-g Space Station mission simulation will be developed to simulate 90 day missions.

SPECIAL REMARKS:

(01) Study constraints are time and completeness. Initial development of criteria for man-machine function allocation must rely upon collation of considerable but inconclusive and disparate information concerning human performance in space. Although this is a constraint, justification for proceeding derives from an increasing, continuing requirement for human factors information throughout system conceptualization, design and development. Commencement now will reduce the number and associated costs of future retrofits necessitated by man's inability to meet system performance requirements.

(02) Johnson Space Center is currently developing portable test batteries for assessing the effects that space mission environments and transitions in environments have upon a variety of bio-functional capabilities required for task proficiency. These test batteries, along with those for the quantitative assessment of task performance, should be employed and validated in Space Shuttle flights as soon as possible. This useage would provide information concerning both bio-functional capabilities and task proficiency that is needed for the design and development of Space Station. Moreover, this usage would ensure that improved versions of the portable test batteries would then be available for on-orbit assessment of the bio-functional correlates of a much wider variety of space tasks.

REFERENCES:

(01) Military Specification: Human Engineering Requirements for Military Systems, Equipment and Facilities, MIL-H-46855B, Amendment 1, 5 April 1982.

(02) Man/System Requirements for Weightless Environments, MSFC-STD-512A, December 1, 1976.

(03) NASA, Lyndon B. Johnson Space Center, RFP 9-BC83-19-3-108, Man/System Integration Standards. JSC-07387A, Crew Station Specifications, Jan. 1982.

(04) Space Station Habitability Report, Boeing Aerospace Co., NASW-3680/CC0081, Feb. 1983.

(05) NASA Headquarters, Life Sciences Division, Human Capabilities in Space, March 1984.

(06) Military Standard: Human Engineering Design Criteria for Military Systems, Equipment and Facilities, MIL-STD-1472C, 10 May 1982.

(07) Nicogossian, A.E. and J.F. Parker (Eds.) Space Physiology and Medicine, NASA SP-447, Washington, DC: U.S. Government Printing Office, 1982.

(08) Johnston, R.S. and L.F. Dietlein (Eds.) Biomedical Results from Skylab, (NASA SP-377), Washington, DC; U.S. Government Printing Office, 1977.

(09) Wiewille, W.W. and D.H. Williges. Operator Mental Workload Assessment: An Annotated Bibliography. Patuxent River, Maryland: U.S. Naval Air Test Center, SY-72R-80, March 1980.

NUMBER	TITLE	DATE
207M03	TASK PERFORMANCE ASSESSMENT	6-25-85

STUDY TASKS:

(01) Conduct a literature review and survey of previous space mission crewmembers and other selected NASA personnel, to identify and rank in priority-of-resolution order those underlying bio-functional determinants of performance that are suspected to change during space flight.

(02) Review NASA and available Soviet documentation of prior space programs, including phases of conceptualization, design, development, test and evaluation, and deployment. Identify those bio-functional capabilities/limitations that accounted for or were associated with marginal performance and with performance that did not meet system requirements due to the inability of man to function as intended. In addition, describe those designs that did not meet system performance requirements and had to be modified. For each instance of marginal and sub-marginal performance, describe the task or task sequence, associated task conditions and bio-functional capability(ies) likely responsible for the marginal or submarginal performance. Analyze tasks, conditions and underlying bio-functional capability involvent to determine if trends or patterns exist within and across programs, tasks, conditions and bio-functional capabilities. Rank order bio-functional capability involvement in terms of frequency of occurrence for each phase of each program.

(03) Combine the information obtained in task 1 and 2 and perform the following subtasks:

(a) Organize, analyze, and extrapolate as possible the current diverse information in knowledge of man's bio-functional capabilities and level of respective capabilities required for different levels of task proficiency.

(b) Develop a preliminary draft of the "International Compendium of Human Factors Information Concerning Man's Capabilities, Performance and Limitations in Space." Ensure that its format and information content is maximally useful to those who allocate system functions and those who design man-man-machine interfaces, life support equipments, crew stations, etc. Include a section that identifies gaps in knowledge of the effects of mission profiles upon bio-functional capabilities and upon task performance.

(c) Identify gaps in technical knowledge of human bio-functional capabilities that are requisite to space task proficiency, and plan and conduct research to resolve the gaps. This will include the following:

Assemble/develop multiple tests and test protocols for quantitatively assessing bio-functional capabilities underlying task proficiency (e.g., visual performance, hand-eye coordination and other sensorimotor capabilities, multiple-task cognitive processing).

Assemble/develop multidimensional tests and test protocols for quantitatively assessing human performance on a broad variety of representative space tasks that may exhibit covariation with different levels of bio-functional performance.

Perform the task proficiency/task degradation testing using subjects in a Space Station mission simulator with typical Space Station mission profiles.

Revise and update the "International Compendium of Human Factors Information Concerning Man's Capabilities, Performance and Limitations in Space" in accordance with findings from simulator testing above.

(04) Identify critical tasks during conceptualization, design, development, test and evaluation and deployment of Manned and Man-Tended Space Stations, ensuring that the individual and collective task requirements are consistent with 1) man's capabilities and limitations and 2) system performance requirements. Use identification methodology such as that described the references (1,6).

(05) For tasks identified as critical: 1) assemble/develop multidimensional performance tests and methodologies for assessing task proficiency during ground training to ensure that task performance is consistent with system requirements for mission safety and success, and 2) identify that subset of critical tests and associated tests for which on-orbit training and performance assessment systems may be required, including systems complete with capability for built-in assessment.

(06) For the subset of critical tasks identified in task (5), assemble/develop portable, multidimensional performance tests and methodologies appropriate for assessment and diagnosis of the status of underlying bio-functional determinants of task performance and verify task assessment in one-g simulation and on Shuttle flights.

(07) Analyze critical task performance and bio-functional data collected in task (06) as a function of mission profile, including determination of the interrelationships between changes in bio-function and changes in task proficiency.

(08) Update the "International Compendium of Multidisciplinary Human Factors Information Concerning Man's Capabilities, Performance and Limitations in Space", using results and appropriate extrapolations from task (7).

SPECIAL STUDY NEEDS:

TASK(S)	NEED
1,2,3(a)	Access to current crew population, NASA experts

	and NASA designers
2	Access to NASA and Soviet documents pertaining to reallocation of system functions and redesign of man-machine interfaces due to human performance falling short of system requirements.
3(b),3(c) 3(c)(4)	Access to personnel (NASA, contractor, and other experts) associated with development of the Man/System Integration Standards
3(c), 6	Access to full scale mock-ups
3(c), 6	Access to mission simulation
6	Shuttle flight experiment

SPECIAL SKILLS:

TASK(S)	SKILL
01,02,03,04 05,06,07,and 08	For all tasks: Multidisciplinary Human Factors Scientists with expertise in the quantitative assessment of bio-functional capability and task performance assessment, Biomedical Engineers and System Design Engineers.

PERFORMING ORGANIZATION:

(01) Managing: NASA JSC (lead)
NASA ARC, MSFC, LaRC (support)

(02) Doing: Aerospace Firms (prime)
Multidisciplinary Human Factors Engineering Consultants (sub)

STUDY PRODUCTS:

(01) List of Space Station critical tasks associated with payloads and station operations.

(02) Identification of bio-functional determinants of performance that appear to change as a function of mission profile, including visual performance and various sensorimotor capabilities.

(03) Portable, multidimensional test batteries for quantitative assessment of effects that mission profiles have upon both task performance and bio-functional capabilities.

(04) Recommendations for built-in test batteries to accomplish the same as (03).

(05) Systematic determination of the effects that mission profiles have upon both task performances and bio-functional capabilities.

(06) Development of criteria and standards for task performance and bio-functional capabilities that are requisites to given levels of system performance.

(07) An "International Compenendium of Multidisciplinary Human Factors Information Concerning Man's Capabilities, Performance and Limitations In Space". (This compendium will complement the "Man/System Integration Standards, Requirements, and Guidelines" currently under development.)

(08) Plan for onboard research to verify magnitude, time course, and individual variability in changes in bio-functional determinants (e.g., visual performance), in zero-g environment over 90 days.

PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS:

SUBELEMENT NO. & TITLE	Undefined Rqmt #
20704 ACCIDENT PREVENTION	-01, -03

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
207M03	TASK PERFORMANCE ASSESSMENT	6-25-85

	1984 O	N	D	1985 J	F	M	A	M	J	J	A	S
FISCAL MONTH	FY 85 1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												
STUDY TASKS												
1. Conduct Literature Review and Interviews										A,B	-------- 6 mm	--------
2. Review Prior Predeployment Space Flight Documentation											-------- 2 mm	--------

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
207M03	TASK PERFORMANCE ASSESSMENT	6-25-85

	1985	1986
CALENDAR	O--N--D--	J--F--M--A--M--J--J--A--S--
FISCAL	FY 86	
MONTH	1 2 3	4 5 6 7 8 9 10 11 12
PHASE B		
C		

STUDY TASKS		
2.	Review Prior Spaceflight Doc.	4 mm
1A.	Analyze and Rank Bio-Functional Determinants/Limiters of Space Performance	1 mm
2A.	Describe Task and Bio-Functional Characteristics of Marginal and Submarginal System Performance	12 mm
2B.	Analyze Predeployment Marginal and Submarginal Characteristics	3 mm
2C.	Compare Predeployment Task and Biofunctional Characteristics for Marginal and Submarginal System Performance	1 mm
2D.	Rank Predeployment Bio-Functional Determinants/Limiters, Comparing with Deployment Ranking	1 mm
3.	Combine & Extrapolate Deployment & Pre-deployment Information Concerning Task Performance & Bio-Functional Capabilities	8 mm
3A.	Identify Gaps in Knowledge of Bio-Functional Requisites to Task Proficiency	2 mm
3B.	Develop Preliminary Draft of International Human Factors Compendium	K 6 mm
3C.	Develop Research Plan to Resolve Gaps in Knowledge identified in Task 3A	3 mm
4.	Identify Critical Tasks and Recommend Changes	8 mm
5.	Assemble/Develop Performance Tests for Assessing Critical Task Performance	10 mm

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
207M03	TASK PERFORMANCE ASSESSMENT	6-25-85

STUDY TASKS	O (1986)	N	D	J (1987)	F	M	A	M	J	J	A	S
FISCAL	FY 87											
MONTH	1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												
5A. Identify Critical Tasks Requiring On-Orbit Training/Assessment	---------- 4 mm											
6. Assemble/Develop Portable Test Batteries for On-Orbit Assessment of Bio-Functional Capabilities and Task Proficiency	--------------- 4 mm											
6A. T&E the Portable Test Batteries on Shuttle Flights & 1-g Sim.					-------------------------- 18 mm							
7A. Validate Extrapolated Human Factors Information									-------------- 4 mm			
8. Update the "International Compendium of Multidisciplinary Human Factors Information Concerning Man's Capabilities Performance and Limitations in Space"									-------------- 4 mm			

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
207M03	TASK PERFORMANCE ASSESSMENT	6-25-85

SUMMARY SCHEDULE/COST FACTORS

STUDY SPAN: JUL 85-SEP 87 CM = 26

CATEGORY	FACTOR/MM(CM)*	COST $
LABOR		
- NASA Project Mgmt		
- Study Mgmt	16 MM	
- Study Tasks		
- Analyst, Eng'g	18 MM	
- Special Skills:		
Human Factors Scientists, Multidisciplinary	59 MM	
Biomedical Engineer	12 MM	
System Design Engineer	12 MM	
SPECIAL FACILITIES		
Neutral Buoyancy Facility	3 CM	
Shuttle Flight	1 CM	
TRAVEL		
Coordination and interviews with NASA personnel and designees		40 K
MATERIALS		
Assembly/Development of test batteries for assessing bio-functional capabilities and task proficiency		400 K
TEST PROGRAM		
One-g Simulator test		500 K
Shuttle flight experiment		1000 + K
OTHER (List)		
Micro computer and peripherals for data entry, analyses, reports and drafting of preliminary compendium		20 K

* MM = Manmonths; CM = Calendar Months

REPORT FORMAT 13 MANAGEMENT PLAN OVERVIEW

NUMBER	TITLE	DATE
209M01	RECREATION	6-27-85

ISSUE #	TITLE	NEED DATE
2090201	FACILITY FOR GROUP RECREATION	OCT 87
2090202	FACILITY FOR INDIVIDUALIZED RECREATION	OCT 87
2090102	O-G REC. ACTIVITIES, EQUIPMENT & MATERIALS	OCT 87
2090101	INDIVIDUAL RECREATIONAL PREFERENCES	OCT 87
2090301	OFF-SHELF RECREATIONAL EQUIPMENT FEASIBILITY	OCT 87
2090501	RECREATION OBJECTIVES	OCT 87
2090302	INNOVATIVE RECREATIONAL PROVISIONS	OCT 87

OBJECTIVES:

(01) To determine the types of group O-g recreation and leisure-time activities which are appropriate and do-able in Space Station

(02) To determine what type(s) of individually unique project/hobbies can be performed in O-g.

(03) To verify crew preferences for the types of O-g activities for group and individual use.

(04) To determine minimal/maximal mass of recreational equipment.

(05) To determine ways to stow, maintain and set-up recreational equipment and materials.

(06) To determine the restraints and access required for O-g recreational equipment, activities and materials.

(07) To determine various methods of providing space for the entire group to meet and participate in activities together.

(08) To determine the amount of volume required for group and individual recreation.

(09) To identify specific areas within Space Station for group and individual recreation facilities.

(10) To determine how the group recreation facilities will be enlarged as the crew size increases with the growth of Space Station.

(11) To determine how the individualized recreation facilities should be structured.

(12) To determine where and how a private TV/video viewing area should be provided.

(13) To develop engineering specifications for (11) and (12) above.

(14) To determine if (11) and (12) above are to occupy the same or different spaces within Space Station.

(15) To determine what off-the-shelf recreational equipment is feasible for Space Station use.

(16) To confirm objectives and goals for group and individual recreation.

BACKGROUND:

It is widely believed that to foster high morale and contentment in Space Station, personal perferences with regard to types of recreational resources should be considered and provided for, insofar as practicable. Prior U.S. space missions have not afforded the space or time for consideration of this factor. Additionally, except for Skylab 4, the mission duration was short enough that lack of recreational variety did not adversely impact performance. The pace of activity was such in earlier missions that there was minimal leisure time available. This will change as we enter the Space Station era, especially in the post-IOC period.

Studies of analogous confined environments (e.g., submarines, Soviet space station, Antarctica, deep submergence habitats - References 1 through 4), indicate that where recreational facilities and leisure time are available, personnel prefer "usual" pursuits such as reading, movie/TV watching, listening to music, and conversation. In the case of space travellers, simply watching Earth is a favorite pastime. Remarkably, a minority of people in confined environments indulge in hobbies and crafts (e.g., wood carving, painting, photographic dark-room work, etc.). Additionally, some people consider extension of their scientific or technical work as an appropriate way to spend leisure time. Some people enjoy exercise, e.g., working out, as recreation. Therefore, it does not appear appropriate to provide for unusual or esoteric types of recreation for Space Station. Experience from the past would argue against providing for these "unusual" pursuits. On the other hand, if a person desires to paint, for example, consideration should be given to his preference insofar as there are not adverse effects, (e.g., flammability or out-gassing) on other station functions.

The realtive time spent doing leisure activities will probably change as the mission length extends and as Space Station operations mature. Technological advances of recent decades should make it easy to incorporate the ability to perform the above activities in seclusion as well as in groups. Flexibility to perform unique hobbies, etc. should be considered.

A location within Space Station large enough to accommodate the entire crew complement will be required for "all hands" business meetings as well as for group recreational purposes serving a few to all crew members. This can most cost-effectively be done by providing a multi-purpose area, (e.g., wardroom) with movable/removable partitions and bulkheads and storage space for recreational materials and/or stowage of facilities/equipment used for other purposes e.g., tables for dining.

A thorough study of man exposed to confined environments (References 1 - 4), reveals that those group activities (two or more people) of greatest popularity are: movies/television viewing (can also be done individually), "bull sessions"/conversation, and playing cards. The other highest-ranking types of leisure-time activities are individual oriented and therefore impact facilities for individualized recreation. Several studies indicate that confinement may initially cause depressive states relieved by group activities and personal interaction. As the period of confinement continues there is a trend from group oriented recreational activity to more single-person recreation.

One goal of group oriented recreational activity in space vehicles has been to devise competitive sports which would subserve both recreation and physical exercise. This goal has proven elusive since at this time such activities do not exist. Such facilities/types of recreation should be identified because astronauts and technical people sometimes have strong competitive urges.

This issue resolution study will entail an integrated analysis of the recreation and leisure requirements leading to a definition of the individual and group activities, facility, equipment and operations specifications.

INPUTS:

A. INTERIOR VOLUME REARRANGEMENT REQUIREMENTS (MANAGEMENT PLAN 106M01)
B. METHODS TO ENHANCE CREW TEAMWORK (ISSUE 3080201)
C. CREW TEAMWORK EFFECTIVENESS (ISSUE 3080301)
D. MINIMUM ACTIVITY AREA VOLUME REQUIREMENTS (IN MANAGEMENT PLAN 101M01)
E. MULTI-USE VERSUS DEDICATED SPACE DETERMINATION (IN MANAGEMENT PLAN 101M01)
F. ZERO-G SPORTS AND GAMES (MANAGEMENT PLAN 207M01)
G. RECREATION/LEISURE TIME REQUIREMENTS (IN MANAGEMENT PLAN 306M01)
H. RESULTS OF PHASE B TRADE STUDIES IMPACTING RECREATIONAL FACILITIES AND STOWAGE

CRITICAL ASSUMPTIONS:

(01) There will be some leisure time for discretionary individual use.

(02) There will be room for storage of recreational activity equipment and materials.

(03) Some leisure activities will be specially configured for Space Station conditions.

(04) There will be space for recreational activities aboard Space Station.

(05) The time available for leisure time activities may change as Space Station matures, with the most likely scenario being the time increasing after the initial IOC period.

(06) Some individuals may consider facilities designed for other functions to subserve their leisure-time preferences, for example, exercise and scientific equipment.

(07) The types of individual recreations enjoyed may change as mission length progresses which may impact recreational facility utilization.

SPECIAL REMARKS:

(01) Liaison established with Ms Jeri W. Brown (NASA JSC SP) indicates that there are no existing contracts/grants from JSC to academia or industry in the area of recreation.

(02) Sufficient data exist from analog studies and the NASA data base regarding psycho-social aspects of leisure-time expenditure in confined environments (References 1-4). Additional formal studies/research area not required in order to provide more-than-adequate recreational provisions for IOC and beyond Space Station.

(03) Laboratory and Space Station mock-up simulations of proposed recreational scenarios, with competing and synergistic functions, should be performed at appropriate government (JSC, ARC) and contractor facilities.

REFERENCES:

(01) Space Station Antarctic Analogs, NASA NAG 2-255, NAGW-659, December 1984.

(02) Space Station Habitability Design Recommendations, Vol. I, Boeing Aerospace Company, D180-28402-1, November 1984

(03) Space Station Habitability Recommendations Based on a Systematic Comparative Analysis of Analogous Conditions, Jack W. Stuster, Anacapa Sciences, Inc., Santa Barbara, CA. December 1984

(04) Soviet Space Stations as Analogs, Boeing Aerospace Company, D180-28182-1, October 1984

NUMBER	TITLE	DATE
209M01	RECREATION	6-27-85

STUDY TASKS:

(01) Review of Space Habitat Analog Literature - Several studies of human beings in confined environments (e.g., submarines, Antarctic "wintering-over", Soviet Space Stations), should be thoroughly reviewed before making decisions regarding recreational facilities. Since the findings, relative to recreation, are consistent between analog models, the lessons to be learned from this review will be vitally important to any decisions regarding facilities and recreation types to be provided.

(02) Survey Crew Recreation Preferences - Conduct informal poll/survey of all U.S. astronauts who have flown in space regarding their opinions on the types of individual recreation/leisure-time pursuits which will drive requirements for facilities and how they could be accommodated in micro-gravity. If this informal survey corroborates reading, conversation, video tape/movie viewing, music listening and Earth watching as preferred recreational activities, it will verify the findings of analogous studies of confined man. This poll should differentiate between "group" and "individual" recreation. In view of the multi-national crew composition, cultural preferences must also be included.

(03) Review Survey Results- Convene a "workshop" and/or poll astronauts and a group of recreation "experts" to evaluate the reasonableness of initial decisions regarding group recreation facilities.

(04) Conduct Analyses and Trades - Integrate data from Tasks 5 thru 11 to determine facilities, equipment and utilities resources available and the associated costs for the provision of recreation and leisure activities. Consider changes in rquirements with crew size changes. Define time allocation for leisure and recreational activities.

(05) Identify Synergistic Recreation Options - Identify innovative/creative exercise apparatus which would subserve both individual recreation and physical exercise needs of crew personnel, perhaps simultaneously. For example, to increase motivation for exercise, a CRT display of an interesting bicycle route through the countryside (for bike ergometer), or of snow-covered terrain (for cross-country skiing machine) could be provided. Alternatively, movie watching and music listening could be synergistic with a workout in this setting. Competitive sports-type games could serve both the recreational and physical exercise needs of the crew complement.

(06) Identify Impact of Mission Scenario on Recreation - The amount of leisure time and the types of personnel aboard may be different in IOC Space Station than it will be in IOC+2, for example. This task will identify flexibility and easy modification of facilities needed to support different mission scenarios.

(07) Determine Constraints on Individual Projects - Determine the constraints on the types of individual projects/hobbies which will be allowed for performance on Space Station during leisure time periods, (e.g., can paperback books be brought on-board in view of flammability requirements).

(08) Determine Limits on Quantity of Recreational Equipment - Determine the amount of recreational equipment which will be permitted aboard the Space Station which will be contigent upon the amount of storage space available for recreational equipment.

(09) Develop Storage Plan - Develop a plan for storage, maintenance and set-up of recreational equipment and materials.

(10) Determine Restraint Requirements - Define the types of restraints (hand-holds, anchors) and access required in use of 0-g recreational equipment, activities, and materials.

(11) Coordinate Recreation Requirements - Coordinate all preliminary decisions/plans regarding recreation with NASA centers dealing with functions which will compete with recreation for various resources.

SPECIAL STUDY NEEDS:

TASK(S)	NEED
4	Facilities - crew systems and human factors laboratories and/or Space Station mock-ups at NASA JSC, NASA ARC and at various contractor sites to validate proposed recreational equipment for space application.
4	Flight tests - fly procedures as Shuttle DTOs to verify candidate recreational equipment and procedures.
2,3	Crew population - access to potential candidate crew personnel and to NASA technical/managerial expertise in this area.

SPECIAL SKILLS:

TASK(S)	SKILL
4,10	Human Factor Engineers/Psychologists

PERFORMING ORGANIZATION:

(01) Managing: NASA JSC SP and/or NASA ARC Space Human Factors Organization

(02) Doing: NASA ARC Human Factors Organization
Prime contractors for Space Station

STUDY PRODUCTS:

(01) Definition of objectives and types of leisure and recreational activities preferred by crew.

(02 Identification of Space Station areas which will function as group and individual recreational facilities.

(03) Detailed procedures for stowage, maintenance and set-up of rec-reational equipment.

(04) Detailed design specifications for recreational facilities and equipment and time allocation based on crew size.

PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS:

SUBELEMENT NO. & TITLE		Undefined Rqmt #
20901	Types (recreation)	-03,-06,-07,-08
20902	Facilities (recreation)	-07,-08,-10,-11
20903	Equipment (recreation)	-05,-06,-07
20905	Criteria (recreation)	-03
20906	Planning	-01,-02,-04,-05, -06,-07,-08,-09, -10,-11,-12
20907	Growth	-01,-02

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
209M01	RECREATION	6-27-85

	1985			1986								
CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S
FISCAL	FY 86											
MONTH	1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												

STUDY TASKS		
1. Review of Space Habitat Analog Literature	B	(1m/m)
2. Survey Crew Recreation Preferences	F	(1m/m)
3. Review Survey Results	C	(2m/m)
4. Conduct Analyses and Trades	A,D,E,H	(8m/m)
5. Identify Synergistic Options		(2m/m)
6. Identify Impact of Mission Scenarios on Recreation	G	(2m/m)
7. Determine Constraints on Individual Projects		(1m/m)
8. Determine Limits on Amount of Recreation Equipment		(2m/m)
9. Develop Plan for Storage, Maintenance and Set-up.		(1m/m)
10. Determine Restraint/Hand-Hold Requirements		(1m/m)
11. Coordinate Recreation With Synergistic or Competing Functions		(1m/m)

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
209M01	RECREATION	6-27-85

SUMMARY SCHEDULE/COST FACTORS

STUDY SPAN: DEC 85-AUG 86 CM = 8

CATEGORY	FACTOR/MM(CM)*	COST $
LABOR		
- NASA Project Mgmt	4 mm	
- Study Mgmt	8 mm	
- Study Tasks		
- Analyst, Eng'g		
- Special Skills:		
- Human Factors Engs/Psychologists	20 mm	
SPECIAL FACILITIES		
- Human Factors Labs/Mock-ups	1 cm	
- Crew Population Access	8 hrs	
- Shuttle Flights	4 hrs	
TRAVEL		
- Trips to JSC, ARC		2 K
MATERIALS		
-Candidate Recreation Equipment		5 K
TEST PROGRAM		
-Lab/Mock-up Tests	1 cm	
- Shuttle DTO	4 hrs	
OTHER (List)		

* MM = Manmonths; CM = Calendar Months

REPORT FORMAT 13 MANAGEMENT PLAN OVERVIEW

NUMBER	TITLE	DATE
211M01	POTABLE WATER	07-19-85

ISSUE #	TITLE	NEED DATE
2110801	METHOD OF HEATING OR COOLING WATER	DEC 86

OBJECTIVES:

(01) To define the optimal method for heating and cooling potable water on the Space Station.

BACKGROUND:

Skylab water was heated to 150 degrees Fahrenheit and cooled to 45 degrees Fahrenheit for food reconstitution. Cooled water was used for drinking. Ambient water temperature was maintained at 60 degrees Fahrenheit. Heating and cooling of water was sufficient for preparation of 3 meals simultaneously. The capacity of the wardroom water cooler was 5.9 lb. and recovery time (time required to cool 5.9 lb. water from 81 degrees Fahrenheit) was 2 hours. The capacity of the wardroom water heater was 4 lb. and recovery time (time required to heat 4 lb. water from 35 degrees Fahrenheit to 152 degrees Fahrenheit) was 90 minutes. A similar water heater was provided for the Waste Management Compartment except that the maximum temperature was 127 degrees Fahrenheit. Water for the whole body shower was heated to a maximum of 105 degrees Fahrenheit.

The Skylab water was cooled in a fin lined reservoir which used refrigeration subsystem primary and secondary coolant to cool the water. The water heater used a strip heater located in the hot water reservoir.

For the STS Orbiter, hot water is available only on those missions which include the galley. On missions without a galley, food is reconstituted with ambient potable water and foods are heated in a portable food heater. Potable water in the Orbiter galley is provided hot (160 dgrees Fahrenheit) or cold (45 degrees Fahrenheit). Hot water is provided by a heating coil in the galley hot water tank and by circulating water around the galley oven to collect waste heat during food heating. Chilled water is provided to the galley from the Orbiter potable water system and no further cooling is accomplished in the galley.

The foregoing systems functioned as required, but it is expected that additional efficiencies can be achieved in the larger SSP system.

INPUTS:

A. Space Station Reference Configuration
B. Phase B Contract Study
C. WATER MANAGEMENT (Issue 20102)

CRITICAL ASSUMPTIONS:

(01) The potable water will need to be part of the food inventory system to keep track of use.

(02) Water heating methods and storage onboard will interface with ECLSS.

SPECIAL REMARKS:

(01) None identified to date.

REFERENCES:

(01) Boeing Aerospace Co., D180-2810-1, Space Station Habitability Report, 28 Feb 1983.

(02) NASA Conference Publication 2370, Food Service and Nutrition for the Space Station, 10 Apr 1984.

(03) G E Report No. 80SDS4240-Contract-Nas9-15743 Shuttle Orbiter Galley Manual, Sep 1980.

REPORT FORMAT 14 STUDY PLAN

NUMBER	TITLE	DATE
211M01	POTABLE WATER	07-19-85

STUDY TASKS:

(01) Perform literature review to evaluate alternative methods for heating and cooling water. Hardware utilized on previous manned missions should be evaluated for compatability with current Space Station requirements. Viable system methods should be identified. Another subtask will be to review NASA and contractors reports for viable water heated/chilled concepts. Areas requiring additional research or technology development will be identified.

(02) Define constraints and design criteria for a Space Station water heater/chiller system. Constraints which will impact the design of a baseline system will include water temperature limits, ECLSS interface, size limitations, material limitations.

(03) Perform trade studies to select a baseline system for heating and cooling Space Station water.

(04) Determine the requirements for additional heating and cooling of water as the Space Station grows. To determine the additional water required per crewmember, the available volumes and heating/cooling needs of all water systems must be known along with predicted Space Station growth rates.

(05) Formulate requirements and specifications for water heating and cooling. Key factors will include material selection, configuration access, environmental control parameters, quantities and recommended location within the Space Station module.

SPECIAL STUDY NEEDS:

TASK(S)	NEED
	None identified to date.

SPECIAL SKILLS:

TASK(S)	SKILL
	None identified to date.

PERFORMING ORGANIZATION:

(01) Manageing: NASA JSC-MSD

(02) Doing: Aerospace Firms (Prime)

STUDY PRODUCTS:

(01) Baseline water heating/cooling definition.

(02) Modification of baseline necessary for growth of SSP.

(03) Water heating/cooling system requirements and specifications.

PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS:

SUBELEMENT NO. & TITLE	Undefined Rqmt #
21108 POTABLE WATER	-02

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
211M01	POTABLE WATER	07-19-85

	1984			1985								
CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S
FISCAL	FY 85											
MONTH	1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												
STUDY TASKS												
1. Perform Literature Review												--- (1 mm)

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
211M01	POTABLE WATER	07-19-85

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                                           1985      |   1986                     |
                                  CALENDAR|O--N--D--|J--F--M--A--M--J--J--A--S|
                                    FISCAL|FY 86                               |
                                     MONTH|1  2  3   4  5  6  7  8  9 10 11 12|
                                   PHASE B|                                    |
                                         C|                                    |
STUDY  TASKS                              |                                    |
1.  (cont)                                |--                                  |
                                          |(1 mm)                              |
                                          |                                    |
2.  Identify Types of Heating/Cooling     |      ---------                     |
                                          |       (3 mm)                       |
                                          |                                    |
3.  Perform Trade Studies                 |              ---------------       |
                                          |                  (9 mm)            |
                                          |                                    |
4.  Determine Additional Water            |                     (---------)    |
    Heating and Cooling Required          |                       (3 mm)       |
    for Growth                            |                                    |
                                          |                                    |
5.  Formulate Requirements                |                            --------|
                                          |                             (2 mm) |
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REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER		TITLE	DATE
211M01	POTABLE WATER		07-19-85

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                                    1986        |     1987                                      |
                           CALENDAR|O--N--D--  |J--F--M--A--M--J--J--A--S|
                             FISCAL|FY 87                                 |
                              MONTH|1  2  3    4  5  6  7  8  9 10 11 12 |
                            PHASE B|                                      |
                                  C|                                      |
STUDY  TASKS                       |                                      |
5.  (cont)                         |-------                               |
                                   |(2 mm)                                |
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REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
211M01	POTABLE WATER	07-19-85

SUMMARY SCHEDULE/COST FACTORS

	STUDY SPAN:	CM =17
CATEGORY	FACTOR/MM(CM)*	COST $
LABOR		
- NASA Project Mgmt	2 mm	
- Study Mgmt		
- Study Tasks	21 mm	
- Analyst, Eng'g		
- Special Skills:		
SPECIAL FACILITIES		
TRAVEL		
To Design Reviews at NASA Centers and Phase B Contractors		3 K
MATERIALS		
Breadboards to verify concept		5 K
TEST PROGRAM		
Ground Tests to Support Trade Studies		10 K
OTHER (List)		

* MM = Manmonths; CM = Calendar Months

REPORT FORMAT 13 MANAGEMENT PLAN OVERVIEW

NUMBER	TITLE	DATE
212M01	HOUSEKEEPING ITEMS & EQUIPMENT	06/13/85

ISSUE #	TITLE	NEED DATE
2120201	CLEANING MATERIALS	NOV 88
2120202	HOUSEKEEPING EQUIPMENT	NOV 88
2120701	HOUSEKEEPING EQUIP - GROWTH REQ.	NOV 88

OBJECTIVES:

(01) To define acceptable levels of cleanliness within the Space Station,

(02) To determine the frequency of performing all housekeeping and cleaning tasks to maintain an acceptable level of cleanliness,

(03) To develop criteria for cleaning equipment and materials, cleansers, biocides, etc.,

(04) And to determine the quantities of housekeeping items and equipment required to maintain a clean and healthy Space Station environment.

BACKGROUND:

Housekeeping and cleaning are among the most tedious and time consuming chores that were noted on Skylab, and the problem still exists on the Shuttle Orbiter. All Crewmembers have participated in housekeeping and cleaning activities, and they perform general and routine housekeeping on both a scheduled and unplanned basis. Housekeeping activities generally include:

- o Food Preparation and galley cleanup,
- o Dining/wardroom area cleanup,
- o Trash collection and processing area cleanup,
- o Sanitizing and restowage of food related utensils,
- o General surface cleaning, walls, ceiling and floors,
- o Fixture cleaning,
- o Personal hygiene equipment cleaning,
- o General restowage (02).

Many of the problems in Housekeeping in of previous spaceflight programs are amenable to correction if identified early in the design phases of the SSP. Accurate identification of requirements and issues and a systematic approach to the resolution of issues will enhance human productivity and effectiveness on SSP missions.

INPUTS:

A. Contamination and Odor Control (Subelement 20103) Requirements.

B. SSP Reference Documents (Housekeeping Provisions).

C. Requirements for Space Station Housekeeping defined in "Space Station Houskeeping and Trash Management Study"(2).

D. Housekeeping Tasks (Subelement 21203).

CRITICAL ASSUMPTIONS:

(01) The perceived level of cleanliness among any crew will be different and very subjective.

(02) Some unscheduled cleaning chores will be done on an as needed basis.

(03) Input B will not be available until PDR.

SPECIAL REMARKS:

(01) A previous study (Space Station Housekeeping and Trash Management Study) performed by ILC Space Systems for NASA JSC-MSD will faciliate the work done under this management plan.

REFERENCES:

(01) Crew Interface Panel, JSC19517. 1983

(02) Space Station Housekeeping and Trash Management Study, ILC-SSD, NAS9-16589, Nov. 1984.

REPORT FORMAT 14 STUDY PLAN

NUMBER	TITLE	DATE
212M01	HOUSEKEEPING ITEMS & EQUIPMENT	06/13/85

STUDY TASKS:

(01) Utilizing data available from prior contamination control literature and studies, prior mission debriefings/experience bulletins, and crew survey inputs, determine acceptable levels of cleanliness within habitable areas of the Space Station. For those cleanliness levels which are subjective, develop guidelines for cleaning frequency and operations. For those areas where specific contamination levels are defined and must be adhered to, develop a list of requirements and procedures for cleaning operations. Particular emphasis will be placed on those contaminates which would endanger crewmember health and safety such as microbial contamination buildup. The frequency of cleaning required to maintain the acceptable level of cleanliness will be defined.

(02) Perform a literature review to identify potentially viable Space Station housekeeping items, materials and equipment. A subtask will be the evaluation of mission results and program reports of previous U.S. and Soviet manned missions in the areas of housekeeping and cleaning. The key elements to be analyzed include wipes (wet, dry, utility and tissues), biocides/cleansers, screens/filters, and vacuum cleaners. The quantity of these equipment items utilized will be identified. Areas in which additional research or technology advancement is required will also be addressed.

(03) Define housekeeping items and equipment necessary to maintain an acceptable level of cleanliness during a 90 day Space Station mission. Considerations will be given to 0-G handling, offgasing, hazards, safety, effectiveness and volume of cleaning liquids and materials. The types of screens, filters and other methods of capture of liquids and solid particulates will be identified.

Equipment required for localized or specific cleaning using negative air pressure will also be defined. Trade studies under this subtask will include: handheld vacuum cleaners vs. centrally located vacuum sources with multiple outlets. The criteria used to perform the trades will include ease of operation, maintainability, cleanability, impact on other subsystems, etc.

A wipe subsystem to facilitate general housekeeping will be defined to include size, configuration and materials. Trades and performance analyses will be performed to select optimum utility dry wipes, wet wipes, biocide wipes and tissues for each houeskeeping task. Trades will include disposable vs. reuseable wipes.

The output of this task shall be a list of acceptable cleaning equipment and materials.

(04) Determine the quantities of housekeeping equipment required to meet required cleanliness levels. Quantities will be based on anticipated housekeeping tasks and frequency of cleaning operations for initial and add-on equipment/module configurations. This task will include determination of replacement items (i.e. filters, screens, etc.) and resupply quantities (i.e. biocides, cleansers, etc.).

(05) Develop requirements and specifications for Housekeeping subsystem.

SPECIAL STUDY NEEDS:

TASK(S)	NEED
	None identified.

SPECIAL SKILLS:

TASK(S)	SKILL
	None identified.

PERFORMING ORGANIZATION:

MANAGING: NASA, JSC-MSD
DOING: Aerospace Firm (Prime)
Industrial Firms (Sub)

STUDY PRODUCTS: DETAILED DESIGN SPECIFICATIONS FOR:

(01) Definition of baseline housekeeping subsystem.

(02) Design requirements and specifications for housekeeping items and equipment.

PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS:

SUBELEMENT NO. & TITLE		Undefined Rqmt #
21202	Cleaning Equipment	-03, -05, -06
21207	Growth	-01

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
212M01	HOUSEKEEPING ITEMS & EQUIPMENT	06/13/85

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                                              1987       |    1988                   |
-------------------------------------CALENDAR|O--N--D--|J--F--M--A--M--J--J--A--S|
                                       FISCAL|FY 88                              |
----------------------------------------MONTH|1  2  3   4  5  6  7  8  9 10 11 12|
                                      PHASE B|                                   |
                                            C|                                   |
STUDY  TASKS_________________________________|___________________________________|
1.  Determine Level of Cleanliness           |  A ------------                   |
                                             |  B     (4 m/m)                    |
                                             |  D                                |
                                             |                                   |
2.  Literature Review                        |            C --------             |
                                             |               (2 m/m)             |
                                             |                                   |
3.  Definition of Housekeeping               |                      ----------- |
    Equipment                                |                        (4 m/m)    |
                                             |                                   |
                                             |                                   |
4.  Define Houskeeping Equipment             |                           --------|
    Quantities                               |                                   |
                                             |                                   |
5.  Requirements & Specifications            |                           --------|
    for Housekeeping Subsystems              |                                   |
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REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
212M01	HOUSEKEEPING ITEMS & EQUIPMENT	06/13/85

	1988			1989								
CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S
FISCAL	FY 89											
MONTH	1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												
STUDY TASKS												
4. Define Houskeeping Equipment Quantities (cont.)	– (3 m/m)											
5. Requirements & Specifications for Housekeeping Subsystem (cont.)	--- (3 m/m)											

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
212M01	HOUSEKEEPING ITEMS & EQUIPMENT	06/13/85

SUMMARY SCHEDULE/COST FACTORS

STUDY SPAN: 10/87 to 12/88 CM =13

CATEGORY	FACTOR/MM(CM)*	COST $
LABOR		
- NASA Project Mgmt	2 m/m	
- Study Mgmt		
- Study Tasks		
- Analyst, Eng'g	16 m/m	
- Special Skills: INDUSTRIAL ENGINEER HUMAN FACTORS ENGINEER		
SPECIAL FACILITIES		
TRAVEL To NASA Centers and contractor facilities for Phase B and other SSP reviews		2 K
MATERIALS For commercially available cleaning agents and equipment		1 K
TEST PROGRAM STS inflight evaluations of potential cleaning equipment		10 K
OTHER (List)		

* MM = Manmonths; CM = Calendar Months

REPORT FORMAT 13 MANAGEMENT PLAN OVERVIEW

NUMBER	TITLE	DATE
213M01	WASTE/TRASH COLLECTION METHODS	06/22/85

ISSUE #	TITLE	NEED DATE
2130202	WASTE/TRASH COLLECTION METHODS	11/86

OBJECTIVES:

(01) To identify effective methods for collecting various types (i.e. solids, liquids, solid-liquid mixtures, solid-liquid-gas mixtures, toxic, corrosive, radioactive, biologically active) of Space Station Waste/Trash;

(02) To determine locations for placing trash receptacles and liners within the various habitable areas of the Space Station;

(03) To determine the number of replacement trash bags required for a nominal 90-day mission;

(04) And to develop requirements and specifications for a trash collection system as well as trash collection equipment.

BACKGROUND:

The method and time required to collect, sort and process trash on Space Station will have a profound effect on Human Productivity. Not only will time be an important factor but the method of controlling contamination will be equally important. Based on previous spaceflight experience and current Space Station reference documentation, trash collection will be a localized task accomplished at the source of trash generation. The crewmember may employ manual techniques to collect the trash or may be assisted by mechanical automated devices such as vacuum cleaners.

Particulates, liquids, small solids and trash items that cannot be captured and retained manually in zero-gravity may be collected by means of a negative pressure device or a flow of entrained air into collection containers. A negative pressure device such as a vacuum cleaner can be used for the collection of particulate solids, vapors, and small quantities of fluids. The vacuum cleaner may be a portable unit(s) or it may be a centrally located vacuum source with multiple outlets. (1,2)

Trash items that can be captured and retained manually in zero-gravity will be deposited in designated trash receptacles. The receptacles may contain removable liners which will contain the trash during transfer, storage and interface with disposal equipment or they may simply provide an inlet port where the trash will be inserted and then automatically transported to storage and/or disposal equipment.(1)

The physical and chemical characteristics of the trash collected will drive the design of trash receptacles and liners. The number of replacement vessels or liners will be determined by the rate at which the particular trash items are generated. The size of the liners will be based on the following criteria:

- o Trash generation rates in specific Space Station architectural areas.
- o Size limitations of the various Space Station hatches, corridors and airlocks.
- o Mass and volume limitations based on crewmember capacity to physically handle and transfer the trash container.

INPUTS:

A. Space Station Trash Generation Model (Issue 2130101)
B. Phase B Study Results (Trash Management Interface Analysis)
C. SSP Reference Documents (Size Limitations of Space Station Hatches, Corridors and Airlocks)
D. Trash Compactor Design (Issue 2130601)
E. Preliminary Space Station Module Layouts

CRITICAL ASSUMPTIONS:

(01) Temporary trash collection points will be located throughout the Space Station modules. Final trash stowage will be centralized in the Logistics module.
(02) Biologically active trash will be collected in separate containers from dry inactive trash and will be disposed of daily.
(03) Data for imputs A, B, C, D, and E will be available by November 1985.

SPECIAL REMARKS:

(01) A previous study, Space Station Housekeeping and Trash Management Study, performed by ILC Space Systems for NASA-JSC Manned Systems Division will facilitate the work done under this management plan.

REFERENCES:

(01) ILC Space Systems, Inc., Space Station Housekeeping and Trash Management Study, (by Martin L. Agrella, F. D. Stevens and M. c. Smith), ILC-10107-70413, NASA Contract No. NAS9-16589, Houston, TX. Nov. 84.

(02) Fairchild Hiller Inc., Housekeeping Concepts for Manned Space Systems, Vol. I, NASA-CR-115045, Long Island, NY., Oct. 1970.

REPORT FORMAT 14 STUDY PLAN

NUMBER	TITLE	DATE
213M01	WASTE/TRASH COLLECTION METHODS	06/22/85

STUDY TASKS:

(01) Perform literature review to identify potentially viable Space Station trash collection systems and equipment. A subtask will be to analyze and evaluate mission results and program reports of the Mercury, Gemini, Apollo, Soyuz, Salyut, Skylab and Shuttle programs in the area of trash collection. Problem areas and failures of the various systems and equipment will be identified. Another subtask will be to review NASA/Contractor reports on proposed Space Station trash collection systems and equipment. Potentially viable alternatives will be identified. Areas in which additional research or technology advancement is required will also be identified.

(02) Identify Space Station unique trash collection system constraints which will have an impact on the size, configuration, material composition, and location of various trash collection equipment items. Constraints such as the size of module hatches and corridors, trash processing equipment interfaces (i.e., trash compactors, vacuum desiccators) and the types and amounts of trash generated in specific areas of the Space Station will be utilized to drive the selection of a baseline trash collection system. Other trash collection system constraints which will be considered include standardized labeling and coding criteria, volume allocations for localized and centralized trash collection, and material constraints.

(03) Perform trade studies on the previously identified system alternatives to arrive at a baseline trash collection system. Key trades will include: localized vs. centralized trash collection; automated vs. manual trash collection; standardized trash receptacles and bags vs. multiple types of trash receptacles and bags.

(04) Determine initial and resupply quantities of consumables, such as trash receptacle liners, for a nominal 90-day/6 crew member mission profile. The first subtask will be to identify all consumables. The second subtask will be to determine the rate at which the consumables will be consumed. For determining the quantities of trash bags required, the available volume of each bag must be known along with predicted Space Station trash generation rates.

(05) Determine the best locations for placing trash receptacles within the various habitable areas of the Space Station. Key factors in determining the location for trash receptacles will be the interior module configuration, the trash generation rates in specific architectural areas of the spacecraft and the size and configuration of the trash receptacles themselves.

(06) Formulate requirements and specifications for a Space Station trash collection system. Design configurations, material composition, quantities and locations of various trash collection equipment will be included.

SPECIAL STUDY NEEDS:

TASK(S)	NEED
01	None identified.

SPECIAL SKILLS:

TASK(S)	SKILL
	None Idenified

PERFORMING ORGANIZATION:

MANAGING: NASA, JSC-MSD

DOING: Aerospace Firms (Prime)

STUDY PRODUCTS:

(01) Baseline Trash Collection System Concepts.
(02) Design Specifications and requirements for a Trash Collection System.

PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS:

SUBELEMENT NO. & TITLE	Undefined Rqmt #
21302 Waste/Trash Collection	-02, -03, -04, -05, -07

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
213M01	WASTE/TRASH COLLECTION METHODS	06/22/85

	1984			1985								
CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S
FISCAL	FY 85											
MONTH	1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												

STUDY TASKS

1. Perform Literatue Review

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
213M01	WASTE/TRASH COLLECTION METHODS	06/22/85

```
                                    1985         :    1986                        :
                            CALENDAR:O--N--D--:J--F--M--A--M--J--J--A--S:
                              FISCAL:FY 86                                        :
                               MONTH:1  2  3   4  5  6  7  8  9 10 11 12:
                             PHASE B:                                             :
                                   C:                                             :
STUDY  TASKS                        :                                             :
1.  Perform Literature Review (Cont) :--                                          :
                                    :(1 m/m)                                      :
                                    :                                             :
2.  Identify S.S. Constraints       :A,B,C ----------                             :
                                    :D,E      (3 m/m)                             :
                                    :                                             :
                                    :                                             :
                                    :                                             :
                                    :                                             :
3.  Perform Trade Studies           :           ----------------                  :
                                    :                 (6 m/m)                     :
                                    :                                             :
4.  Determine Resupply Quantities   :                            ---              :
                                    :                         (1 m/m)             :
                                    :                                             :
5.  Determine Receptacle Locations  :                                       ---   :
                                    :                                   (1 m/m)   :
                                    :                                             :
6.  Formulate Requirements and      :                    ----------------:
    Specifications                  :                                             :
```

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
213M01	WASTE/TRASH COLLECTION METHODS	06/22/85

```
                                      1986          |    1987                                  |
                           CALENDAR|O--N--D--|J--F--M--A--M--J--J--A--S|
                             FISCAL|FY 87                                                  |
                              MONTH|1   2   3    4   5   6   7   8   9  10  11  12|
                            PHASE B|                                                          |
                                  C|                                                          |
STUDY  TASKS                       |
6.  Formulate Requirements and     |---
    Specifications                 |(4 m/m)
    (cont.)                        |
```

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
213M01	WASTE/TRASH COLLECTION METHODS	06/22/85

SUMMARY SCHEDULE/COST FACTORS

STUDY SPAN: 09/85 - 11/86 CM =14

CATEGORY	FACTOR/MM(CM)*	COST $
LABOR		
- NASA Project Mgmt	3	
- Study Mgmt		
- Study Tasks	16	
- Analyst, Eng'g		
- Special Skills:		

SPECIAL FACILITIES

TRAVEL 2K

1. Trip to Marshall Spaceflight Center for Configuration Data
2. Trips to California for Phase B Study Input

MATERIALS

Trash Bag Material Evaluations (Breadboards) 5K

TEST PROGRAM

Trade Study Evaluations (Fabricate Breadboards) 8K

OTHER (List)

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* MM = Manmonths; CM = Calendar Months

REPORT FORMAT 13 MANAGEMENT PLAN OVERVIEW

NUMBER	TITLE	DATE
213M02	CONTINGENCY TRASH DISPOSAL METHOD	06/22/85

ISSUE #	TITLE	NEED DATE
2130701	CONTINGENCY TRASH DISPOSAL METHOD	SEP 1986

OBJECTIVES:

(01) To assess and establish alternative methods and design requirements for contingency trash disposal (e.g., space ejection vs jettison to earth for aerodynamic incineration).

(02) And to develop requirements and specifications for contingency trash disposal equipment.

BACKGROUND:

Based on current Space Station definition and preliminary design criteria, the logistics module will serve the dual purpose of carrying supplies for the Space Station crewmembers and providing storage volumes for both biologically active and inactive trash. Subsequent retrieval of the Logistics Module at 90 day intevals will allow accumulated trash to be removed from the Space Station and disposed of routinely on Earth. Because disposal utilizing the Logistics Module/Shuttle will be the primary mode of trash elimination, other disposal methods such as "direct ejection into space", "jettisoning to Earth for aerodynamic incineration" and temporary stowage alternative locations/stowage areas in the Hab/Lab Modules will be considered as possible contingency methods.

The Soviets have shown that ejection of trash directly into space provides a relatively simple and effective means of waste disposal. The method for contingency trash disposal on the Skylab Orbital Workshop was to eject trash into space by use of the scientific airlocks. Despite the seemingly attractive merits of this method, there are several important concerns which must be addressed.

The critical question is not how to eject trash from the spacecraft, but where will the resulting debris go when ejected. Only two relatively large perturbing forces affect the orbit of Earth orbiting satellites. The first is caused by the Earth's oblateness and the second is caused by atmospheric drag. Both forces will cause the satellite (trash bag) orbit to gradually decay. An ejected trash bag's resulting orbit as well as its orbital lifetime is a function of several parameters including its initial altitude, inital orbit eccentricity, drag coefficient, projected area and ejection velocity (01).

It was determined that on Skylab the use of one or both of the scientific airlocks as a means of ejecting trash into space could have created the possibility of trash bags recontacting the Skylab. The

Skylab and trash bag orbits could have theoretically crossed at two points during each revolution, although they may not have necessarily passed the points at exactly the same time. It was determined that short term collision could be avoided if the jettison velocity was greater that 1 ft./sec. and if jettison occurred near orbital morning or evening (3).

In addition to the possibility of Space Station collision with an orbiting trash bag, there is a serious concern about possible contamination of the atmosphere surrounding the spacecraft. The long-term effect of a polluted atmosphere could result in a gradual surface depositing of pollutants on thermal control coatings, spacecraft windows, optical surfaces and solar arrays.

Because of the desire to minimize pollutants around the spacecraft, one possible contingency disposal method would be to jettison a trash container back to earth's atmosphere for aerodynamic incineration. A solid rocket booster could be used as the propellant. Deployment of the trash rocket from the Space Station would require a spin-up for stability prior to ejection and then ejection at low velocity to minimize reaction forces. This would be analogous to the way the Shuttle orbiter presently deploys satellites. A mini-rocket or spring force could be used to impart an initial small acceleration to the "Trash Rocket", followed by the main thrust after the rocket is adequately removed from the station (1,2).

INPUTS:

A. Space Station trash generation model (Issue 2130101)

B. Contamination and odor control (subelement 20103) requirements.

C. Preliminary Space Station Module layouts (Airlock Locations).

D. Trash disposal methods defined in the "Space Station Housekeeping and Trash Management Study" (01).

CRITICAL ASSUMPTIONS:

(01) Contingency trash disposal methods will only be employed when the primary trash management system fails or overloads.

(02) Data inputs from A, B, C and D will be available by IRR.

SPECIAL REMARKS:

(01) Coordination with Ames Research Center (work package 1 and 3) for disposal of toxic chemicals and biologically active materials will be required.

(02) A previous study, Space Station Housekeeping and Trash Management Study, performed by ILC Space Systems for NASA JSC-MSD will facilitate the work done under this management plan.

(03) Output of this management plan will be input to subelement 20654 (contingency body waste/trash management).

REFERENCES:

(01) ILC Sppce Systems, Inc., Space Station Housekeeping and Trash Management Study (by Martin L. Agrella, F. D. Stevens, and M. C. Smith), ILC 10107-20413, NAS9-16589, Nov. 1984.

(02) Fairchild Hiller Inc., Housekeeping Concepts for Manned Space Systems, Volume I, NASA-CR-115045, Long Island, NY, Oct. 1970.

(03) G. A. Singer, Advanced Trash Management System", (with W. H. Hanlon and F. E. Senator), Proc. Intersociety Conf. On Environmental Systems, ASME PUB. 73 ENAS-31, San Diego, CA July 1973.

(04) JSC-19989, Space Station Reference Configuration Description, NASA-JSC, August 1984.

REPORT FORMAT 14 STUDY PLAN

NUMBER	TITLE	DATE
213M02	CONTINGENCY TRASH DISPOSAL METHOD	06/22/85

STUDY TASKS:

(01) Perform literature review to identify feasible alternatives for contingency trash disposal. A subtask will be to analyze and evaluate contingency trash disposal techniques utilized on previous manned U.S. and U.S.S.R. spaceflight programs. Another subtask will be to review NASA/Contractor reports on proposed Space Station contingency trash disposal methods. Potentially viable alternatives will be identified. Areas in which additional research or technology advancement is required will also be identified.

(02) Perform trade studies on alternative contingency trash disposal methods. Key trades will include: temporary utilization of alternative stowage locations in the Hab/Lab Modules vs. direct ejection into space vs. ejection into a vented holding tank vs. jettison towards earth for aerodynamic incineration. The criteria to be used in the trade studies will include but not be limited to crew health and safety, complexity of operation, time required to perform the task, development and operational costs, and impact on the Space Station external configuration and environment.

(03) Formulate requirements and specifications for a contingency trash disposal system. Design configurations, material composition, quantities and locations of various contingency trash disposal equipment (e.g. trash airlocks and/or trash ejectors) should be included.

SPECIAL STUDY NEEDS:

TASK(S)	NEED
	None identified to date.

SPECIAL SKILLS:

TASK(S)	SKILL
	None identified to date.

PERFORMING ORGANIZATION:

MANAGING:	NASA, JSC-MSD
DOING:	Aerospace Firms (Prime) Consultants (Sub)

STUDY PRODUCTS:

(01) Requirements and specifications for contingency trash disposal system(s) which will not contaminate the Space Station internal or external environment.

PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS:

SUBELEMENT NO. & TITLE	Undefined Rqmt #
21307 Trash Disposal	-02

REPORT FORMAT 13 MANAGEMENT PLAN OVERVIEW

NUMBER	TITLE	DATE
213M03	WASTE/TRASH GENERATION MODEL	06/24/85

ISSUE #	TITLE	NEED DATE
2130101	WASTE/TRASH PREDICTION MODEL	06/30/86

OBJECTIVES:

(01) To establish a Space Station trash generation model (amounts, types and loactions) based upon cost, probable mission profiles and systems characteristics;

(02) To identify habitable areas within the Space Station where hazardous waste materials are being produced.

BACKGROUND:

The first step in developing an efficient housekeeping/trash management system for Space Station is to accurately identify possible trash items and their rates of production. These rates and trash item characteristics can then be used to establish the materials, processes, and routines to collect, transfer, treat, and dispose of each trash item (01).

Before trash items and their rates of production can be determined, consumables/expendables in each architectural area of the Space Station must be identified. The major sources of consumables/expendables as identified on previous manned missions include crew meals, crew hygiene provisions, crew clothing, crew ancillary provisions, housekeeping provisions, data aquisition and management (i.e. teleprinter), biotechnology and human research experiments, and animal studies (02).

Based on past missions, typical trash items generated as the various consumables/expendables are used include food remnants, food packaging, wipes, napkins, wash cloths, towels, contingency fecal/urine/emesis bag, teleprinter paper, clothing, cleaning rags, and storage bags (02).

Results from a study conducted by Manned System Division of NASA (02) on Shuttle Orbiter trash generated during missions STS-5 and 41C showed average trash generation rates of 0.40 cubic feet/man-day and 2.95 lbs/man-day. Of trash produced, approximately 70 percent was wet biologically active trash (i.e. food and accessories, wet wipes, toliet paper, towels/wash cloths, fecal/urine/emesis bags, odor filters, etc.)

INPUTS:

A. Preliminary Space Station Functional Allocations - W.P. -02 Phase B Study

B. NASA In-House Trash Generation Studies

CRITICAL ASSUMPTIONS:

(01) Trash items generated on the Space Station will be similar in nature to those generated on Skylab and the Shuttle Orbiter.

(02) Clothing, towels, wash cloths, and dining utensils will be cleaned/washed and reused. These items will, therefore, not be considered potential trash items.

SPECIAL REMARKS:

(01) Analyses performed by Rockwell Corporation in the areas of Space Station Food, Waste and Hygiene Subsystem Design resulted in a 12 man Space Station waste model. See reference 3, this information will facilitate the work done under this management plan.

(02) Trash generation during the MDAC/NASA sponsored 90-day manned Space Station simulator test was monitored and recorded in test reports. See reference 4, this information will facilitate the work done under this management plan.

(03) Shuttle Orbiter trash generation during missions STS-5 and 41C was studied by Manned Systems Division of NASA. See reference 2, this information will facilitate the work done under this management plan.

(04) A previous study, Space Station Housekeeping and Trash Management Study, performed by ILC Space Systems for NASA-JSC Manned Systems Division will facilitate the work done under this management plan.

REFERENCES:

(01) ILC Space Systems., Inc., Space Station Housekeeping and Trash Management Study, (By Martin L. Agrella, F. D. Stevens, and M. C. Smith), ILC-10107-70413, NASA Contract No. NAS9-16589, Houston, Tx., Nov. 1984.

(02) Manned Systems Division, NASA-JSC. IVA Hardware Monthly Status Review, April 1984.

(03) North American Rockwell Co., Inc., Space Station Food, Waste and Hygiene Subsytem Design (By G. C. Schaedle and B. Barnett), SD71-209, Presented to ASMA/AIAA Symposium on Habitability In Space Stations, Houston, Tx., April 28, 1971.

(04) McDonnell Douglas Astronautics Co., Inc., Test Report/Test Results - Operational Ninety-Day Manned Test of a Regenerative Life Support System, NASA-CR-111881, 1971.

REPORT FORMAT 14 STUDY PLAN

NUMBER	TITLE	DATE
213M03	WASTE/TRASH GENERATION MODEL	06/24/85

STUDY TASKS:

(01) Identify consumables/expendables (i.e. food, food packaging, wipes, napkins, tooth brushes, toothpaste, etc.) in each architectural area of the Space Station to include: the galley/wardroom, personal hygiene area, and workstations. Review of previously performed trash generation studies (i.e. theoretical, simulator, flight) will assist in the identification of consumables/expendables.

(02) Estimate the rate at which the consumables/expendables will be consumed. The consumption rate should be defined in consistent units (i.e. lbs. per crew member per day). Previously performed simulator tests and theoretical studies will be used as a data base when mission results are not available.

(03) Identify resulting waste/trash items and rates of generation in each architectural area. Physical and chemical characteristics of the resulting trash items will be defined. Physical characteristics should include the physical state (i.e. solid, liquid, gaseous) and physical attributes (i.e. soft, hard, flexible, rigid, etc.) of the trash items. Chemical characteristics should include factors which will influence trash processing (i.e. organic, toxic, radioactive, etc.). Each area of the Space Station which generates trash will be rank ordered in terms of greatest to least trash generation.

(04) Identify areas within the Space Station where hazardous waste/trash materials are being produced. Harzardous materials will be defined as materials which would have an adverse effect on the health of the crew (i.e. toxic, radioactive, pathogenic, etc.). The results of task 3 will be used to accomplish this task.

SPECIAL STUDY NEEDS:

TASK(S)	NEED
	None identified to date.

SPECIAL SKILLS:

TASK(S)	SKILL

None identified to date.

PERFORMING ORGANIZATION:

(01) MANAGING: NASA, LSC Training Organization
DOING: Aerospace Firms (prime)

STUDY PRODUCTS:

(01) A list of potential trash items which will result from various Space Station activities and provisions.
(02) The rate at which various Space Station trash items are produced.
(03) A list of architectural areas within the Space Station where hazardous waste/trash items are being produced.
(04) A list of areas which is ordered from greatest to least in terms of trash generation.

PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS:

SUBELEMENT NO. & TITLE	Undefined Rqmt #
21301 Waste/Trash Generation	-01, -02, -03, -04

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
213M03	WASTE/TRASH GENERATION MODEL	06/24/85

```
                                          1984      ¦    1985                            ¦
                                 CALENDAR¦O--N--D--¦J--F--M--A--M--J--J--A--S¦
                                   FISCAL¦FY 85                                          ¦
                                    MONTH¦1  2  3   4  5  6  7  8  9 10 11 12¦
                                  PHASE B¦                                               ¦
                                        C¦                                               ¦
STUDY  TASKS                             ¦                                               ¦
1.  Identify Consumables/Expendables     ¦                                 A,B ---¦
                                         ¦                                               ¦
2.  Estimate Consumption Rates           ¦                                      --¦
```

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER: 213M03

TITLE: WASTE/TRASH GENERATION MODEL

DATE: 06/24/85

```
                                         1985        |    1986                          |
                                 CALENDAR|O--N--D--|J--F--M--A--M--J--J--A--S|
                                   FISCAL|FY 86                                      |
                                    MONTH|1  2  3   4  5  6  7  8  9 10 11 12|
                                  PHASE B|                                           |
                                        C|                                           |
STUDY  TASKS                             |                                           |
1.  Identify Consumables/Expendables     |------                                     |
    (cont.)                              |(4 m/m)                                    |
                                         |                                           |
2.  Estimate Consumption Rates           |----                                       |
    (cont.)                              |(2 m/m)                                    |
                                         |                                           |
3.  Identify Trash Types and Amounts     |       ------------                        |
                                         |          (4 m/m)                          |
                                         |                                           |
4.  Identify Harzardous Trash            |              --------------               |
    Generation Areas                     |                 (2 m/m)                   |
                                         |                                           |
```

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
213M03	WASTE/TRASH GENERATION MODEL	06/24/85

SUMMARY SCHEDULE/COST FACTORS

STUDY SPAN: 08/85 - 06/86 CM =10

CATEGORY	FACTOR/MM(CM)*	COST $
LABOR		
- NASA Project Mgmt	2 mm	
- Study Mgmt		
- Study Tasks	12 mm	
- Analyst, Eng'g		
- Special Skills:		

SPECIAL FACILITIES

TRAVEL

1. Trips to NASA Centers and Phase B Study Contractors for Inputs and Consultation. 3 K

MATERIALS

TEST PROGRAM

OTHER (List)

* MM = Manmonths; CM = Calendar Months

REPORT FORMAT 13 MANAGEMENT PLAN OVERVIEW

NUMBER	TITLE	DATE
213M05	WASTE/TRASH TRANSFER EQUIPMENT	06/24/85

ISSUE #	TITLE	NEED DATE
2130501	WASTE/TRASH TRANSFER EQUIPMENT	05/30/87

OBJECTIVES:

(01) To define the operations and tasks required to efficiently transfer waste and trash;
(02) And to identify the equipment and supplies necessary for waste and trash transfer.

BACKGROUND:

Trash transfer will be required to transport trash items from their various collection and processing points to their final disposal or reutilization points. The activities to accomplish this task will involve the movement of trash along corridors, between decks, through hatches, airlocks and tunnels. The approach of the issue resolution of this management plan is to determine the most efficient procedure for the crewmember to perform these tasks. They may be accomplished by strictly manual activities or a combination of manual activities which interface with various automated systems.

The following baseline transfer capability considerations must be addressed in the development of viable transfer system design concepts and operational procedures; intra-station transfers; inter-station transfers; and shuttle or cargo module to station transfers; docked shuttle to station and docked cargo/passenger module to station.

INPUTS:

A. Trash Generation Model (Issue 2130101)
B. Waste and Trash Collection Methods (Issue 2130202)
C. Crew/Equipment Translation and Handling Aids (Subelement 10206)

CRITICAL ASSUMPTIONS:

(01) Trash receptacle liners will be removed from the receptacles and disposed of on a periodic basis. Biologically active trash will be disposed of daily.
(02) Need date for inputs A and B is IRR.
(03) Need date for input C is May 86

SPECIAL REMARKS:

(01) The Space Station Housekeeping and Trash Management Study performed by ILC Space Systems for NASA JSC-MSD will facilitate the work done under this management plan.

REFERENCES:

(01) Space Station Housekeeping and Trash Management Study, ILC Space Systems Division, NAS9-16589, Nov. 1984.
(02) SEB No. 7, JSC-09546, "An Overview of IVA Personal Restraint Sytem", Oct. 1974.
(03) SEB No. 11, JSC-09545, "Personal Mobility Aids", Jan 1975.

REPORT FORMAT 14 STUDY PLAN

NUMBER	TITLE	DATE
213M05	WASTE/TRASH TRANSFER EQUIPMENT	06/24/85

STUDY TASKS:

(01) Perform a literature review to identify potentially viable Space Station waste/trash transfer equipment. A subtask will be to analyze and evaluate mission results and program reports of previous U. S., Soviet and present Shuttle Orbiter waste/trash transfer equipment and techniques. Problem areas identified will include restraint systems, locomotion aids, obstruction of spacecraft corridors and equipment and potential failures of the transfer equipment. Areas in which additional research or technology advancement is required shall also be identified.

(02) Define the tasks and techniques required to secure waste/trash items in their liners; remove liners from the receptacles; install new liners and prepare the trash/waste items for transfer to their designated processing and storage area. Inputs from Waste/Trash Collection Methods (Issue 2130202) will facilitate completion of this task. Trade study analysis to determine the best waste/trash tasks and techniques will be dependent on time constraints (including traffic patterns), complexity and ease of operation, and safety constraints.

(03) Identify the equipment required to effectively transfer waste and trash through the Space Station. Inputs will be required regarding Trash Generation Model (Issue 2130101), and Crew/Equipment Translation and Handling Aids (Subelement 10206). Manual waste/trash transfer aids such as handrails, handholds, restraints (foot & body) and other supportive devices will be evaluated. Automated waste/trash transfer equipment which will be evaluated include a conveyor belt, monorail, and pneumatic transfer systems. Trade studies will be performed to determine the most effective, easy to operate and use, and non-obstructive locomotion aids. Trade studies will be performed on manual vs automated vs combination transfer systems and fixed vs portable restraints.

(04) Formulate requirements and specifications for Space Station waste/trash transfer subsystem. Design configurations, quantities and locations of locomotion aids and waste/trash transfer equipment will be included.

SPECIAL STUDY NEEDS:

TASK(S)	NEED
	None identified to date.

SPECIAL SKILLS:

TASK(S)	SKILL
	None identified to date.

PERFORMING ORGANIZATION:

(01) MANAGING: NASA, JSC-MSD
DOING: Aerospace Firms (Prime)
Industrial Firms (Sub)

STUDY PRODUCTS:

(01) Definition of a baseline waste/trash transfer subsystem.
(02) Design requirements and specifications for waste/trash transfer equipment.

PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS:

SUBELEMENT NO. & TITLE		Undefined Rqmt #
21305	Waste/Trash Transfer Equipment	-01

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
213M05	WASTE/TRASH TRANSFER EQUIPMENT	06/24/85

	1985			1986								
CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S
FISCAL	FY 86											
MONTH	1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												
STUDY TASKS												
1. Literature Review	----	---- (2 m/m)	----									
2. Definition of Tasks	A,B	----	----	----	---- (3 m/m)	----	----	----				
3. Identification of Waste/Trash Transfer Equipment								C	----	----	----	----

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
213M05	WASTE/TRASH TRANSFER EQUIPMENT	06/24/85

	1986			1987								
CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S
FISCAL	FY 87											
MONTH	1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												
STUDY TASKS												
3. Identification of Waste/Trash Transfer Equipment (cont.)	---------------- (6 m/m)											
4. Formulate Requirements and Specifications					-------- (3 m/m)							

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
213M05	WASTE/TRASH TRANSFER EQUIPMENT	06/24/85

SUMMARY SCHEDULE/COST FACTORS

STUDY SPAN: 11/85 - 05/87 CM =19

CATEGORY	FACTOR/MM(CM)*	COST $
LABOR		
- NASA Project Mgmt	2 mm	
- Study Mgmt		
- Study Tasks	14 mm	
- Analyst, Eng'g		
- Special Skills:		
SPECIAL FACILITIES		
TRAVEL To NASA Centers and Phases B Contractors for Design Reviews and Inputs		2 K
MATERIALS		
TEST PROGRAM		
OTHER (List)		

* MM = Manmonths; CM = Calendar Months

REPORT FORMAT 13 MANAGEMENT PLAN OVERVIEW

NUMBER	TITLE	DATE
213M06	TRASH COMPACTOR REQUIREMENTS	06/24/85

ISSUE #	TITLE	NEED DATE
2130601	TRASH COMPACTOR REQUIREMENTS	06/30/87

OBJECTIVES:

(01) To define trash compator design requirements for volume, weight, power, duty cycle, compaction ratio, etc.
(02) And to identify compactor quantity and location needs.

BACKGROUND:

A system for trash compaction would significantly reduce the volume required for trash storage. Commercially available trash compactors have a compaction ratio (volume reduction) of approximately 4 to 1 or 5 to 1 depending on the model (01). Studies have been conducted at NASA with a modified commerical compator designed to provide a 3 to 1 compaction ratio. Test results using the NASA compactor and a trash composition of selected Shuttle Orbiter trash items revealed that the actual compaction achieved was approximately 2.5 to 1. This was due mainly to the fact that certain trash items, such as High Density Polyethylene food containers, tended to return to their original shape after compaction. It was also believed that incompressible fluids remaining in the trash helped to limit the volume reduction attained (02).

Results from compaction tests performed by Industrial Ecology Corportation on dry trash obtained from the NASA/MDAC 90-day manned simulation showed that a pressure of approximately 15 psi was required to achieve a 4 to 1 volume reduction and 19.5 psi was required to achieve a 5 to 1 volume reduction (03). Commerical compactors utilize a ram plate pressure of approximately 18 psi. The key factors which influence the achievable trash volume reduction are the ram pressure and the physical characteristics of the trash items which are being compacted.

It can be argued that the simplest and most cost effective way to supply a trash compactor for use on the Space Station would be to modify a commercially available unit. There are several constraints, however, that would make the use of a commercially available unit very difficult. The electric motor may not be compatible with the Space Station power supply. The electrical switches are of the standard unsealed microswitch variety and would present an electrical spark hazard. General wiring, lubricants, insulation, sealents, plastics, and paints are not compatible with current spacecraft out gassing and flammability specifications (04). In addition, trash compactor and interfacing trash bags are not designed for zero-g containment trash.

INPUTS:

A. Space Station Trash Generation Model (issue 2130101)
B. Preliminary Phase B Study Results (Trash Compactor Interface Analysis)
C. Results from NASA Trash Compactor Tests.
D. Results from Industrial Ecology Corporation Trash Compactor Tests.
E. Preliminary Space Station Module Layout Concepts.

CRITICAL ASSUMPTIONS:

(01) Inputs A, B, C, D, and E will be available by the IRR.

SPECIAL REMARKS:

(01) Results from tests performed by NASA-JSC Manned Systems Divisions on a modified commercial trash compactor will be utilzed to facilitate the work done under this management plan.
(02) Results from tests performed by Industrial Ecology Corporation on a prototype trash compation unit will facilitate the work done under this management plan.

REFERENCES:

(01) ILC Space Systems, Inc., Space Station Housekeeping and Trash Management Study, (By Martin L. Agrella, F. D. Stevens and M. C. Smith), ILC-10107-70413, NASA Contract No. NAS9-16589, Houston, Tx., Nov 1984.
(02) Manned Systems Division, NAS-JSC. IVA Hardware Monthly Status Review, April 1984.
(03) Industrial Ecology Corporation, The Design and Fabrication of a Prototype Trash Compacting Unit, NASA-CR-134292, 1973.
(04) Singer, G. A., W. H. Handon and F. E. Senator. Advanced Trash Management System. ASME Publication 73-ENAS-31, presented at the Intersociety Conference on Evironmental Systems, San Diego, Calif., July 16 - 19, 1973.

REPORT FORMAT 14 STUDY PLAN

NUMBER	TITLE	DATE
213M06	TRASH COMPACTOR REQUIREMENTS	06/24/85

STUDY TASKS:

(01) Perform literature review to identify potentially viable Space Station trash compactor concepts. This will involve reviewing and evaluating NASA/Contractor test results and report on proposed trash compactor concepts. Potentially viable alternatives should be identified. Commercially available compactors and corresponding technology should be evaluated as well for possible upgrade and modification to meet spacecraft requirements. Areas in which research and technology is required shall also be identified,

(02) Identify Space Station unique constraints and design drivers which will have an impact on the size, configuration, material composition, and functions of a baseline trash compactor design. Constraints such as the available power supply, the compactibility of generated trash items offgassing and odor control requirements, trash generation rates, and the method of stabilizing biologically active trash should be defined.

(03) Perform trade studies on viable compactor alternatives to arrive at a baseline trash compactor design. Key trade criteria on which alternative systems are to be evaluated will include the ability of the compactor to handle wet trash; the ability of the compactor to control offgasses and odors; the resulting compaction ratio; ease of operation; development cost; operational cost; system compatibility; impact on other subsystems, reliability, maintainability, life cycle, weight, volume, safety, noise and power consumption. Trades should also performed to determine if more than one type compactor design (i.e. wet trash compactor in the galley, dry trash compactor in the workstation) is warrented.

(04) Establish quantities and locations for a baseline trash compactor. Key factors in determining the quantities and locations of trash compactors will include the exterior volume and configuration of the compactor itself; the trash volume capacity of the compaction chamber; trash generation in specific architectural areas of the spacecraft; and the interior module configuration (i.e. volume allocations and layouts).

(05) Formulate requirements and specifications for a Space Station trash compactor. The requirements and specifications should address handling of expelled gasses and liquids; interface with Space Station power supply; maintenance; duty cycle; compaction force and/or ram pressure; weight, volume, controls and displays, acceptable noise levels and power consumption limits. Trash compactor quantities and locations should also be addressed.

SPECIAL STUDY NEEDS:

TASK(S)	NEED
	None identified to date.

SPECIAL SKILLS:

TASK(S)	SKILL
	None identified to date.

PERFORMING ORGANIZATION:

(01) MANAGING: NASA, JSC-MSD
DOING: Aerospace Firms (Prime)

STUDY PRODUCTS:

(01) Baseline Trash Compactor Definition
(02) Quantities and locations for Space Station Trash Compactors
(03) And Design Specifications and Requirements for a Trash Compactor.

PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS:

SUBELEMENT NO. & TITLE	Undefined Rqmt #
21306 Trash Volume Reduction	-01, -04

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
213M06	TRASH COMPACTOR REQUIREMENTS	06/24/85

```
                                     1985        |    1986                              |
                            CALENDAR|O--N--D--|J--F--M--A--M--J--J--A--S|
                              FISCAL|FY 86                                |
                               MONTH|1  2  3   4  5  6  7  8  9 10 11 12|
                             PHASE B|                                    |
                                   C|                                    |
STUDY  TASKS                        |                                    |
1.  Perform Literature Review       |      C,D ---------                 |
                                    |           (3 m/m)                  |
                                    |                                    |
2.  Identify Constraints and Design |                                    |
    Drivers                         |               B -------            |
                                    |                 (3 m/m)            |
                                    |                                    |
3.  Perform Trade Studies           |                            -------|
                                    |                                    |
                                    |                                    |
                                    |                                    |
```

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
213M06	TRASH COMPACTOR REQUIREMENTS	06/24/85

	1986			1987								
CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S
FISCAL	FY 87											
MONTH	1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												
STUDY TASKS												
3. Perform Trade Studies (cont.)	----	----	----	----								
		(6 m/m)										
4. Establish Quantities and Locations for Compactors		A,E	----	----								
			(2 m/m)									
5. Formulate Requirements and Specifications						----	----	----				
						(4 m/m)						

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
213M06	TRASH COMPACTOR REQUIREMENTS	06/24/85

SUMMARY SCHEDULE/COST FACTORS

STUDY SPAN: 01/86 - 06/87 CM =17

CATEGORY	FACTOR/MM(CM)*	COST $
LABOR		
- NASA Project Mgmt	2 mm	
- Study Mgmt		
- Study Tasks	18 mm	
- Analyst, Eng'g		
- Special Skills:		
SPECIAL FACILITIES		
TRAVEL Travel to NASA Centers and Phases B Contractor facilities for Design Reviews and Inputs To consult with commerical manufacturers of trash compators		4 K
MATERIALS Commercially available Trash Compactors/Componants		2 K
TEST PROGRAM		
OTHER (List)		

* MM = Manmonths; CM = Calendar Months

REPORT FORMAT 13 MANAGEMENT PLAN OVERVIEW

NUMBER	TITLE	DATE
214M02	MODULE DOCKING AIDS	07-19-85

ISSUE #	TITLE	NEED DATE
2140102	MODULE DOCKING AIDS	SEP 88

OBJECTIVES

(01) Develop requirements for Space Station module docking operations, docking aids and procedures.

BACKGROUND:

Starting with initial build-up of the Space Station, and continuing throughout its lifetime, logistics modules will be subjected to many docking and berthing events. Each such event is inherently hazardous and must be treated as a unique, non-routine task, with safety the uppermost consideration. Module docking and berthing currently are planned to be under direct flight crew control rather than being controlled automatically or from the ground. This requires, first, that carefully conceived and proven equipment and procedures must be provided to accomplish these functions, and secondly, that all astronauts potentially having such responsibilities must be thorougly trained in the requisite operations. It is probable that once resupply of the operational Space Station becomes essentially routine (90-day cycle), no single astronaut will perform the task more than two or three times, in his/her career and, therefore, experience retention will be minimal. Accordingly, every effort must be made to provide the safest and most effective module docking aids possible. The equipment and procedures developed for docking and berthing must be reliable and compatible with crew capabilities, and the training resources used must enable fully comprehensive understanding of the tasks to be performed.

This issue resolution management study will identify significant module docking procedures, module docking aids, training equipment, and training documentation. Schedules and cost estimates for the total effort will be generated.

The intent of this study is not to define the design of the docking and berthing interface mechanisms. Rather, it is concerned with the physical aids and operational procedures needed to assure that each module docking activity is carried out by controlling personnel (whether ground- or space-based) in the safest and most efficient manner.

INPUTS:

A. Logistics module docking and berthing mechanism concepts from WP-01 studies.

B. Recommendations of astronauts, NASA engineers, Shuttle and Spacecraft designers, based on actual experience, concerning 1) docking mechanisms and visual proximity aids, and 2) astronaut training needs.

C. Recommendations of lighting experts as to quantity, power levels, control methods, displays, locations, etc., of auxiliary light sources and monitoring positions through the power tower structure.

D. Reports and data, as applicable, generated for the following Human Productivity Management Plans:
216M01 TRANSFER AND TRANSLATION AIDS
301M01 ON-ORBIT TRAINING
306M03 IVA/EVA TASKS AND LEARNING CURVES

E. NASA Document JSC-19989, "Space Station Reference Configuration Description", (J8400076), Aug 1984

CRITICAL ASSUMPTIONS:

(01) This study will be performed in parallel with, and will provide inputs to the module docking/berthing interface design trade studies being conducted by WP-01 contractors.

SPECIAL REMARKS:

(01) Reference No. 2 contains information concerning Space Station assembly, manipulator operations, orbital procedures, proximity and lighting considerations, resupply, and berthing and docking. It is a recommended point of departure for accomplishing this Management Plan.

(02) The video tape noted in Reference No. 3 is a computer-generated, animated, three-dimensional representation of the Space Station reference assembly sequence described verbally in Reference No. 2. It is an additional source of information to be used during this study. The sequence used in Reference No. 2 and in the tape differs significantly from the earlier version given in Reference No. 1, and is considered to be much closer to the probable final concept.

(03) It is recommended that progress and results of the effort accomplished under Reference No. 4 be supplied on a continuing basis to the contractor performing the study defined by this management plan. This is to assure that the output of this study will be fully compatible with the berthing and docking mechanisms to be incorporated into the Space Station.

(04) For purposes of this Management Plan, the term "berthing" is considered to be an emplacement of an element onto the Space Station by use of a Remote Manipulator System (RMS). "Docking" is considered to mean self-engagement of an element with the Space Station, using the element's on-board Reaction Control System (RCS), without recourse to an external device.

REFERENCES:

(01) Space Station Program Description Document, Book 6, System Operations, Dec 1983

(02) NASA Document JSC-19989 (J8400006), "Space Station Reference Configuration Description".

(03) NASA Video Tape, "United States Space Station Assembly Scenario", narrated by Mark Craig, Apr 1985

(04) NASA/MSFC Solicitation No. 8-1-5-EP-33312, "Space Station Berthing Mechanisms".

REPORT FORMAT 14 STUDY PLAN

NUMBER	TITLE	DATE
214M02	MODULE DOCKING AIDS	07-19-85

STUDY TASKS:

(01) Identify Berthing/Docking Interfaces - Identify logistics module mechanism interfaces associated with berthing and docking operations.

(02) Identify Impacting Factors - Identify environmental and dynamic factors affecting berthing and docking operations. This includes natural and artificial lighting, station structural dynamics, manipulator dynamics, etc.

(03) Identify Crew Functions - Define functionsl flows. Perform man/machine function allocation analysis to identify astronaut functions required to perform berthing and docking operations. Including EVA, Shuttle-based and Space Station-based IVA activities.

(04) Identify Ground Control Functions - Identify ground control functions required to perform on-orbit module docking operations.

(05) Identify Module Berthing and Docking Aids - Perform task analysis to identify berthing and docking aids required for safe performance.

(06) Define Communications Requirements - Define flight and ground communication requirements to ensure safe performance.

(07) Define Implementing Software - Define all software required to implement docking and communication functions.

(08) Prepare Detailed Specifications - From the results of Tasks 5, 6, and 7, prepare detailed design specifications for unique docking aid equipment, and software.

(09) Establish Policies and Procedures - From results of Tasks 3 and 4, establish policies and procedures for accomplishing module berthing and docking safely and efficiently.

(10) Identify Tasks Required - From the task analysis in Task 5, identify tasks requiring specialized astronaut training.

(11) Define Crew Training Requirements - From the tasks identified in Task 10, define astronaut training requirements for application of module berthing and docking procedures and aids.

(12) Identify Training Aids and Documentation Requirements - From the results of Task 11, identify simulators, training aids and documentation to support astronaut training.

(13) Prepare Schedules - Prepare schedules for implementing all aspects of this management plan.

(14) Prepare Cost Estimates - Prepare cost estimates for acquisition of docking aids, software, and training and training equipment requirements.

SPECIAL STUDY NEEDS:

TASK(S)	NEED
3,5,8,9,10,11	Access to candidate crew population, docking/berthing equipment designers, and lighting experts.
1,2,3,4,6,12	Availability of Space Station System characteristics including all modules, major orbiting elements, structural features, and impacting environmental factors
14	Availability of pertinent cost factors.

SPECIAL SKILLS:

TASK(S)	SKILL
3,5,9	Crew Systems Engineers
6	Space Communications Engineer
7	Software Specialist
10,11,12	Training Specialist

PERFORMING ORGANIZATION:

(01) Managing: NASA-JSC (Level B)

(02) Doing: WP-02 Aerospace Contractors

STUDY PRODUCTS:

Detailed design specifications for Module Docking Aids.

Recommended policies and procedures for Module Docking Aids usage.

Definition of astronaut training requirements, training aids and documentation.

Recommended schedule for Module Docking Aids implementation.

Cost estimate for total Module Docking Aids acquisition.

PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS:

SUBELEMENT NO. & TITLE	Undefined Rqmt #
21401 RESUPPLY REQUIREMENTS	-05

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
214M02	MODULE DOCKING AIDS	07-19-85

	1986			1987								
CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S
FISCAL	FY 87											
MONTH	1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												
STUDY TASKS												
1. Identify Berthing/Docking Interfaces								A --- (1 mm)				
2. Identify Impacting Factors									C E --- (1 mm)			
3. Identify Crew Functions									B D ---	--- (2 mm)		
4. Identify Ground Control Functions										--- (1 mm)		
5. Identify Module Berthing and Docking Aids											---	--- (4 mm)

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
214M02	MODULE DOCKING AIDS	07-19-85

	1987			1988								
CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S
FISCAL	FY 88											
MONTH	1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												
STUDY TASKS												
5. Identify Module Berthing and Docking Aids	(4 mm)											
6. Define Communication Requirements		(3 mm)										
7. Define Implementing Software			(4 mm)									
8. Prepare Detailed Specifications				(6 mm)								
9. Establish Policies/Procedures					(2 mm)							
10. Identify Tasks Requiring Training						(2 mm)						
11. Define Crew Training Requirements							(3 mm)					
12. Identify Training Aids and Documentation Requirements								(3 mm)				
13. Prepare Schedules										(1 mm)		
14. Prepare Cost Estimates										(4 mm)		

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
214M02	MODULE DOCKING AIDS	07-19-85

SUMMARY SCHEDULE/COST FACTORS

STUDY SPAN:	MAY 87-AUG 88 CM = 16	
CATEGORY	FACTOR/MM(CM)*	COST $
LABOR		
- NASA Project Mgmt		
- Study Mgmt	10 mm	
- Study Tasks		
- Analyst, Eng'g	14 mm	
- Special Skills:		
- Crew Systems Engrs	12 mm	
- Space Commun. Engrs	3 mm	
- Software Specialists	4 mm	
- Training Specialists	8 mm	
SPECIAL FACILITIES		
TRAVEL		
- Coordination with NASA		10 K
MATERIALS		
TEST PROGRAM		
OTHER (List)		

* MM = Manmonths; CM = Calendar Months

REPORT FORMAT 13 MANAGEMENT PLAN OVERVIEW

NUMBER	TITLE	DATE
214M03	INVENTORY MANAGEMENT SYSTEM DEVELOPMENT	07-16-85

ISSUE #	TITLE	NEED DATE
2140201	INVENTORY MANAGEMENT SYSTEM DEVELOPMENT	JAN 89

OBJECTIVES:

(01) Develop the requirements for an Inventory Management System (IMS) which will indicate status of all items in the Space Station requiring continuous accountability.

(02) Configure the IMS to track each item in the on-board inventory, and to exhibit current location and quantity of same upon command.

BACKGROUND:

Astronaut experience has revealed numerous shortcomings in past and current on-board inventory management systems. Problems have been encountered in such areas as nomenclature, retrieval procedures, erroneous packaging and/or labeling, availability and location. The long-duration nature and the technological scope of the Space Station will seriously compound these problems unless careful advanced analysis and planning are undertaken to define appropriate courses of action. A system will be needed on the Space Station that will provide reliable removal and replacement procedural information and on-going status of spares (ORU's) and consumables.

A single inventory data base will be required which can be accessed and modified by the flight or ground crews in real time. These functions should be operable with the system on-line and with appropriate safeguards to prevent accidental or inaccurate modifications. The IMS should provide an information storage and retrieval capability which can be maintained and updated as it evolves through the life cycle of each station element. It must portray equipment status accurately and efficiently, furnish comprehensive coverage of the total in-flight system, be compatible with crew capabilities, be easy to update, and be capable of fast response in reflecting the effect of new data inputs.

INPUTS:

A. Descriptions and analyses of IM systems currently in use or planned for space programs, or for other appropriate program where applicable.

B. Reports and data generated for following HP Issues:

MGMT PLAN	ISSUE	
1. 101M01		COMPARTMENT ARRANGEMENT AND VOLUME GUIDELINES. INCLUDES:
	1010401	MULTI-USE VS DEDICATED SPACE CRITERIA

2.		1020201	EVA ORU MAINTENANCE ACCOMMODATIONS REQUIREMENTS
3.	103M01		INTERIOR DESIGN GUIDELINES. INCLUDES:
		1030301	COLOR, LABEL & PATTERN CODING CRITERIA
4.	103M02	1030302	INTERIOR LOCATION COORDINATE SYSTEM
5.	109M01		EQUIPMENT & FOOD STOWAGE; IOC & GROWTH INCLUDES:
		1090101	STOWAGE CONFIGURATION
6.	109M02	1090401	DATA FILE STOWAGE REQUIREMENTS
7.		2110302	AUTOMATIC FOOD INVENTORY SYSTEM
8.		2140202	LOCATION OF ON-BOARD SPARES
9.	218M01	2180601	ON-ORBIT CONFIGURATION MODIFICATIONS VERIFICATION
10.	218M08	2180302	EQUIPMENT STATUS MARKING ON-ORBIT
11.		3030401	RADIATION-DAMAGED PARTS REPLACEMENT
12.		3030502	LEVEL OF ORU
13.		3050401	GROUPING OF ON-BOARD TOOLS

<u>CRITICAL ASSUMPTIONS</u>:

(01) On-board communication and data processing systems will be capable of handling, storing and transmitting the volume of data involved.

(02) Data requirements of all work packages will be correlated through a suitable authority to ensure compatibility and commonality among all data elements, their terminology, formats and transmission.

(03) Computer operations and associated software will be truly "user-friendly" to preclude procedural or mechanical difficulties, particularly at times of emergency or other stress.

<u>SPECIAL REMARKS</u>:

(01) The all-inclusive nature of this Issue will require close coordination among all work package functional elements throughout the term of the study to assure that problem areas, features of special interest to the flight crew, ground support requirements, requisite procedures, uplink and downlink technical aspects, etc., are given full consideration. It is recommended that a special working group be established, headed by Level B, to integrate the various factors involved.

(02) Video technology should be sufficiently advanced by the time this Issue is worked that new, individualized methods of display and realtime interaction should be possible and exploited. Just how this can best be accomplished and to what extent information transfer can be accommodated is not known at this time.

(03) One approach which should be fully investigated is to locate the principal data base at a ground facility. This would minimize on-orbit data storage and facilitate on-going software update, which would probably continue for most of the program duration. The amount of data required to fulfill the intent of this Issue is expected to be considerable and may well be the subject of separate analysis. The investigation should include an analysis of the impact of loss of signal (LOS), and identify corrective measures which should be taken in such an event.

(04) It should be noted that Solicitation No. 8-1-5-EL-27582, entitled "Space Station Logistics Simulation and Data Base Development", (04) from MSFC includes a requirement for development of an Inventory Management Plan per DR No. 7. The contract, awarded to Martin Marietta Corp. on 23 Feb. 85, will run for three years to February, 1988. The DR description reads: "To define the contractor's planned method of developing an Inventory Management System/Program. To determine what the proposer plans to include in the management system and how the information is to be used." It is recommended that the Martin Marietta study be reviewed, and compared with the study defined by this management plan, to eliminate redundant efforts and to assure that a fully comprehensive system is achieved.

(05) Overall design of the IMS will include the capability to retrieve and display crew and vehicle procedures (e.g., maintenance, on-line test), mission plannint information, failure history, etc. to support on-orbit O&M activities.

REFERENCES:

(01) Space Station Program Description Document: Book 6, System Operations, Dec 1983

(02) Space Station Habitability Report, Boeing Aerospace Co., D180-28180-1, Feb 1983

(03) Space Station Habitability Design Recommendations, Vol. I, Boeing Aerospace Company, D180-28401-2, Nov 1984

(04) NASA/MSFC Solicitation No. 8-1-5-EL-27582, "Space Station Logistics Simulation and Data Base Development".

REPORT FORMAT 14 STUDY PLAN

NUMBER	TITLE	DATE
214M03	INVENTORY MANAGEMENT SYSTEM DEVELOPMENT	07-16-85

STUDY TASKS:

(01) Select Space Station Elements for IMS Inclusion - Select Space Station elements to be covered by the IMS, including ORU's, consumables, and miscellaneous supplies.

The intent is to select (from the Space Station total on-orbit inventory of equipment, other configuration hardware and on-board resources) all items potentially requiring removal, repair, replacement and/or replenishment, for which identification and accountability may be required. This will involve, not only a complete and comprehensive review of the total SS configuration, but also, during that process, considered judgment as to whether an item under review should be entered into the Inventory Management System.

(02) Identify IMS Capabilities Required - Identify IMS functional capabilities to be provided, such as:
a. Track and display status of each item in the inventory.
b. Provide storage location of each inventory item.
c. Store, update and retrieve inventory and logistics information
d. Depict pictorially (video display) each inventory item subject to potential on-board maintenance or requiring visual confirmation of identity. Video display or other pictorial techniques may utilize photographs, outline or envelope drawings, or advanced technology devices such as holographs. Nomenclature is a very definite factor and has been mentioned as a concern by the astronauts. Each item should have one, and only one, name for reference purposes to avoid any confusion in its identification. A number should NOT be part of that name.

(03) Determine IMS Function(s) to be Operative for Each Space Station Element - Determine, for each Space Station element identified in Task 1, the IMS functions(s) that will be operative. (It is conceivable that not all functions will apply to all elements)

(04) Perform Retrieval/Display Analysis - Perform analyses and trades to determine the appropriate data retrieval and display methods. Consider:
a. Display formats
b. Command and data formats
c. Traceability
d. Conversions etc.
Select desired approach.
Obtain recommendations of astronauts based on actual inventory of control experience and projected concepts.

(05) Define Implementing Hardware - Define flight and ground hardware necessary to implement desired approach. Figures 1 and 2 depict candidate solutions.

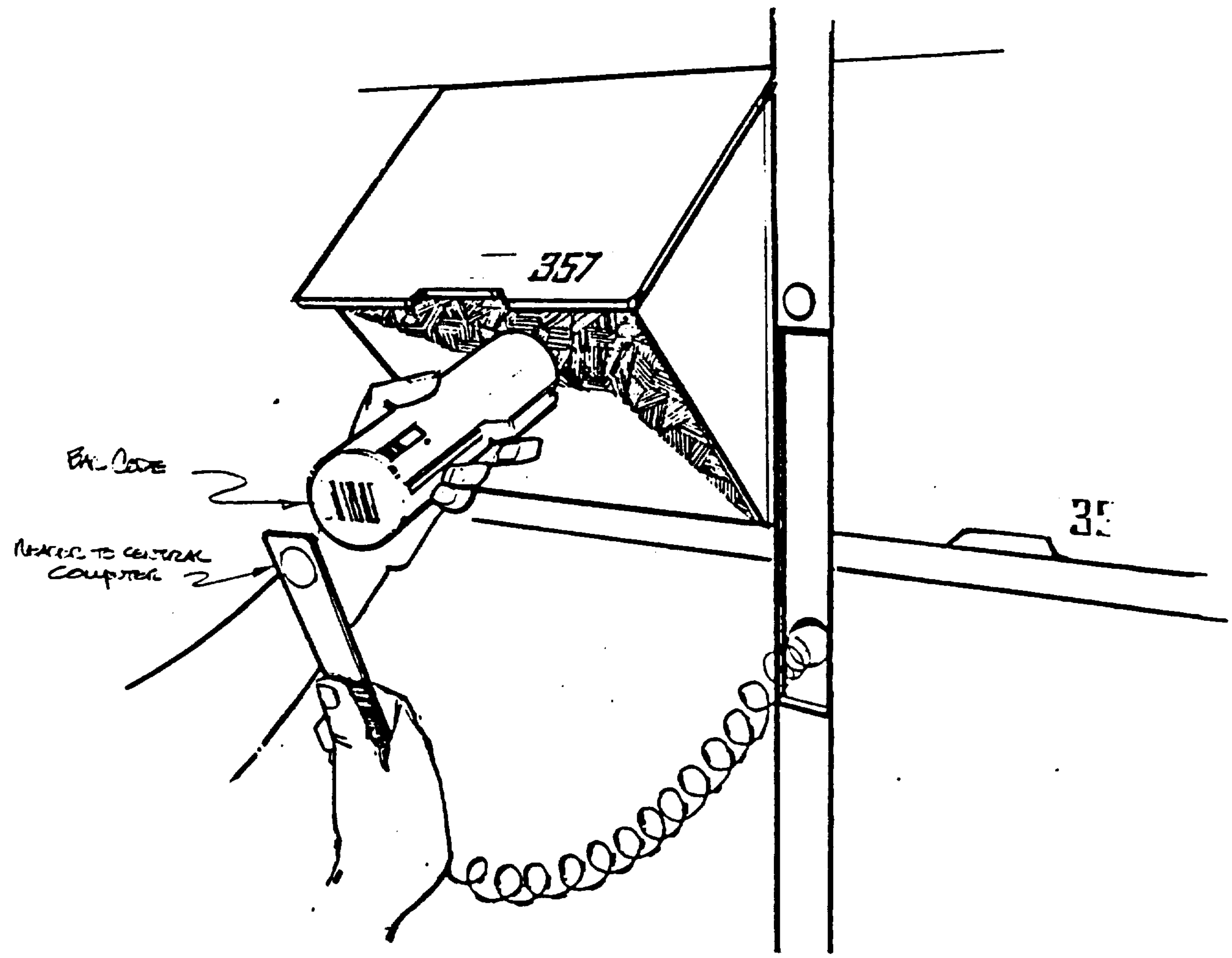

FIGURE 1 (Management Plan 214M02)
BAR CODE TRANSMISSION TO INVENTORY
RECORDS INDICATING EQUIPMENT LOCATION

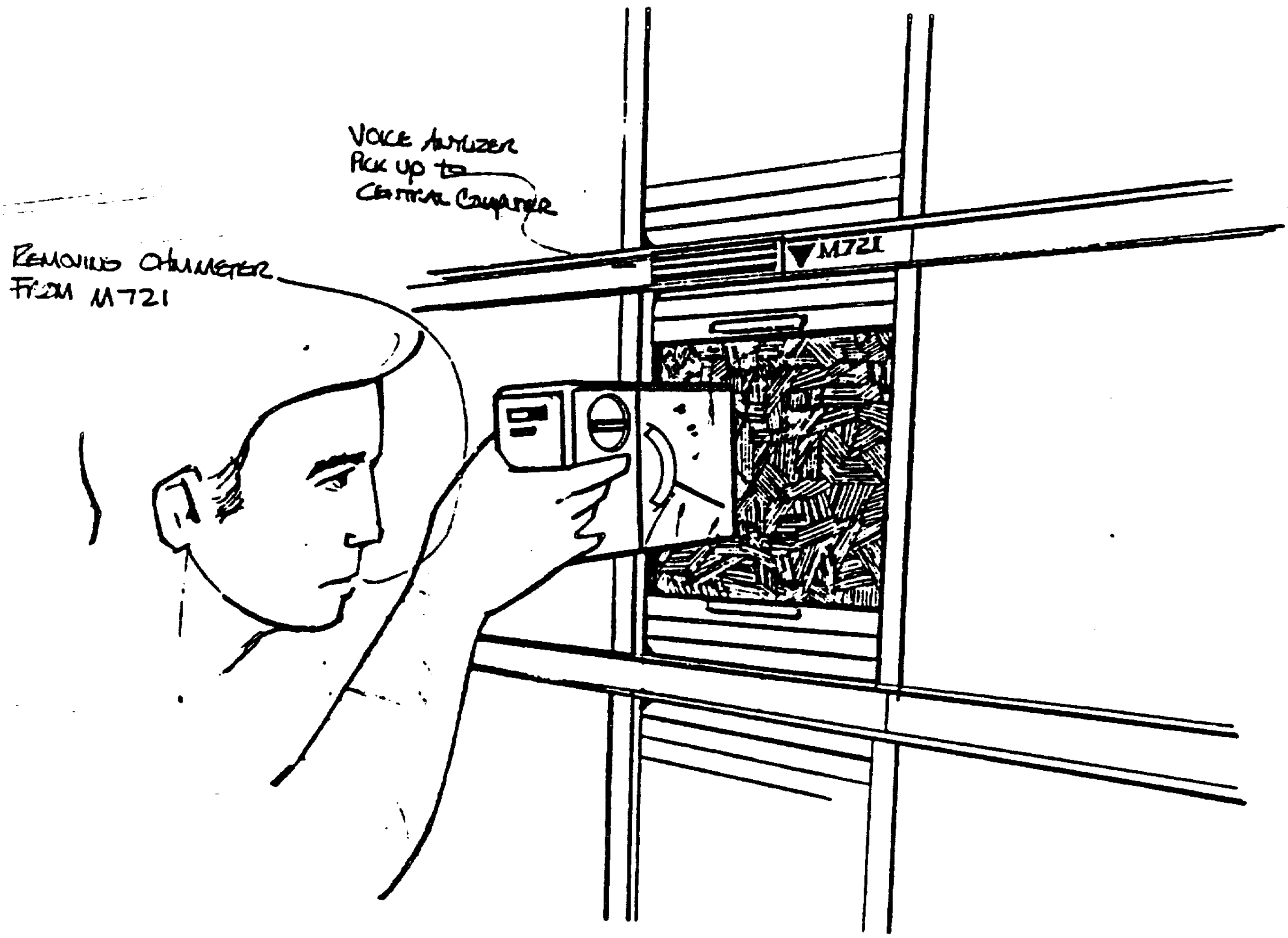

FIGURE 2. (Management Plan 214M02)
VOICE RECORDING OF REMOVAL ACTION
FOR STATUS TRACKING PURPOSES

(06) Define Implementing Software - Define software necessary to implement desired approach

(07) Construct Operational Model - Construct full-scale operating model of on-board and ground-based elements to confirm control and display approaches, demonstrate man-machine interactive functions, and provide initial training capability.

(08) Define Up/Downlink Loading - Define uplink and downlink loading requirements.

(09) Analyze Impact of Loss Of Signal (LOS) - Analyze impact of LOS and identify appropriate corrective measures.

(10) Tailor IMS Concepts to Constraints - Tailor IMS concept as necessary to conform with communication and data storage constraints.

(11) Review Reports and Data - Review and evaluate associated reports and data for compatibility (including but not necessarily limited to listing under paragraph C, Inputs, Report Format 13). Verify that final IMS concept meets Management Plan Objectives as stated in Format 13.

(12) Prepare Detailed Specifications - Prepare detailed IMS design specification.

(13) Establish Policies/Procedures - Establish policies and procedures for efficient use of the IMS.

(14) Prepare Schedules - Prepare system implementation schedules.

(15) Prepare Cost Estimates - Prepare cost estimates for IMS acquisition, including O&M procedures for critical elements, training requirements for utilization and servicing, spares, and any other support needs.

(16) Provide Quarterly and Final Reports - Prepare and provide quarterly and final reports.

SPECIAL STUDY NEEDS:

TASK(S)	NEED
1,4,12	Access to candidate crew population and data display experts.
2,7	Availability of Space Station configuration and resource data; all modules and functional elements.
8	Availability of uplink/downlink system characteristics.
9	Definition of Space Station communication and storage constraints.
14	Availability of pertinent cost factors.

SPECIAL SKILLS:

TASK(S)	SKILL
6	Software Specialists
8,9	Space Communications Engineers
4,5,7	Crew Systems Engineers (including a stowage expert)
2,5,7,11,14	Industrial Engineers
2,3,4,12	Astronauts with Flight Experience

PERFORMING ORGANIZATION:

(01) Managing: NASA, Level B

(02) Doing: Aerospace Firms (Prime)
Computer Firms (Sub)

STUDY PRODUCTS:

(01) Detailed design specification for the Inventory Management System.

(02) Recommended schedule for IMS implementation.

(03) Cost estimate for total IMS acquisition.

(04) Recommended policies and procedures for IMS usage.

PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS:

SUBELEMENT NO. & TITLE	Undefined Rqmt #
21402 INVENTORY MANAGEMENT SYSTEM DEVELOPMENT	-01, -02, -04

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
214M03	INVENTORY MANAGEMENT SYSTEM DEVELOPMENT	07-16-85

```
                                     1986       |   1987
                            CALENDAR|O--N--D--|J--F--M--A--M--J--J--A--S|
                              FISCAL|FY 87                              |
                               MONTH|1  2  3   4  5  6  7  8  9 10 11 12|
                             PHASE B|                                   |
                                   C|                                   |
STUDY  TASKS                        |                                   |
                                    |                B2                 |
                                    |                B5                 |
                                    |                B8                 |
                                    |                B11                |
                                    |                B12                |
                                    |                B13                |
                                    |                   ---             |
1. Select Space Station Elements    |                  (1 mm)           |
   For IMS Inclusion                |                    A              |
                                    |                    B3             |
                                    |                    B4             |
                                    |                    B10            |
2. Identify IMS Capabilities Required                       ---         |
                                    |                     (1 mm)        |
                                    |                     B1            |
3. Determine IMS Function(s) to be  |                      -----------  |
   Operative for Each Space Station |                        (3 mm)     |
   Element.                         |                                   |
                                    |                                   |
16. Provide Quarterly and Final     |                         -         |
    Reports                         |                                   |
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REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
214M03	INVENTORY MANAGEMENT SYSTEM DEVELOPMENT	07-16-85

```
                                         1987        |    1988                                   |
                                 CALENDAR|O--N--D--- |J--F--M--A--M--J--J--A--S|
                                   FISCAL|FY 88                                   |
                                    MONTH|1  2  3   4  5  6  7  8  9 10 11 12|
                                  PHASE B|                                        |
                                        C|                                        |
STUDY  TASKS                             |                                        |
                                         |B6                                      |
4. Perform Retrieval/Display Analysis|------                                  |
                                         |(2 mm)                                  |
5. Define Implementing Hardware          |  -----------                           |
                                         |     (4 mm)                             |
6. Define Implementing Software          |          --------------                |
                                         |              (8 mm)                    |
7. Construct Operational Model           |            ---------------             |
                                         |                  (10 mm)               |
8. Define Up/Downlink Loading            |            ---------                   |
                                         |             (3 mm)                     |
9. Analyze Impact of LOS                 |                 ------                 |
                                         |                 (2 mm)                 |
10.Tailor IMS Concepts to Constraints|                     ------             |
                                         |                     (2 mm)             |
11. Review Reports and Data              |                         ------         |
                                         |                         (2 mm)         |
12. Prepare Detailed Specifications      |                           --------|
                                         |                            (6 mm)      |
16. (cont)                               |-         -        -        -
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REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
214M03	INVENTORY MANAGEMENT SYSTEM DEVELOPMENT	07-16-85

```
                                      1988      |   1989                          |
                              CALENDAR|O--N--D--|J--F--M--A--M--J--J--A--S|
                                FISCAL|FY 89                              |
                                 MONTH|1  2  3   4  5  6  7  8  9 10 11 12|
                               PHASE B|                                   |
                                     C|                                   |
STUDY  TASKS                          |                                   |
13. Establish Policies/Procedures     |------                             |
                                      |(2 mm)                             |
14. Prepare Schedules                 |---                                |
                                      |(1 mm)                             |
15. Prepare Cost Estimates            |---------                          |
                                      |(4 mm)                             |
16. (cont)                            |-     ----Final                    |
                                      |(4 mm total)                       |
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REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
214M03	INVENTORY MANAGEMENT SYSTEM DEVELOPMENT	07-16-85

SUMMARY SCHEDULE/COST FACTORS

STUDY SPAN: MAY 87-DEC 88 CM =20

CATEGORY	FACTOR/MM(CM)*	COST $
LABOR		
- NASA Project Mgmt		
- Study Mgmt	10 mm	
- Study Tasks		
- Analyst, Eng'g	14 mm	
- Special Skills:		
- Computer Specialists	8 mm	
- Space Comm. Engineers	9 mm	
- Shop Technician	10 mm	
- Crew Systems Engrs.	6 mm	
- Industrial Engrs.	8 mm	
SPECIAL FACILITIES		
- None identified		
TRAVEL		
- Coordination with NASA, Subcontracor(s)		15 K
MATERIALS		
- Operational model fabrication		50 K
TEST PROGRAM		
- Test equipment for operational model; astronaut review; model update and refinement.		20 k
OTHER (List)		

* MM = Manmonths; CM = Calendar Months

REPORT FORMAT 13 MANAGEMENT PLAN OVERVIEW

NUMBER	TITLE	DATE
215M01	IVA CREW RESTRAINTS	05-31-85

ISSUE #	TITLE	NEED DATE
2150101	FOOT RESTRAINTS	Apr 87
2150201	BODY RESTRAINTS	Apr 87
2150501	CREW PORTABLE RESTRAINT SYSTEM	Apr 87

OBJECTIVES:

(01) Develop an effective standardized foot restraint system throughout the station that will accommodate the anthropometric range of crew foot sizes.

(02) Develop a versatile body restraint system throughout the space station to supplement the foot restraint, as needed. The body restraint system should be fully adjustable, permit the full range of crew operations about the attachment point(s), and permit free use of both hands.

(03) Develop a portable, adjustable crew restraint system that will permit crew member positioning and stabilization at all non-workstation activity locations throughout the station.

BACKGROUND:

A considerable body of spaceflight experience has been obtained with regard to IVA crew restraint systems extending from the early Mercury, Gemini, Apollo flights to the more recent or current Skylab, Space Shuttle and Spacelab activities. The first reference provides an excellent historical review of IVA crew restraints used to date, along with a delineation of advantages and disadvantages associated with each specific restraint system. From this review it can be concluded that:

o Existing restraint systems have not been found to be universally satisfactory to their users.

o Restraint systems developed to date have not satisfied performance requirements for all crew activities.

o The users of earlier and existing restraint systems are in disagreement as to the value and effectiveness of specific restraint techniques or mechanisms.

o While existing restraint systems have generally not prevented task completion, it is evident that optimized restraint systems and mobility aids can contribute markedly to enhanced human productivity and user satisfaction; optimization is especially important for long duration missions.

The present issue resolution plan provides a technical approach for optimizing the IVA crew restraint system to the point that it will not degrade the proficiency of task performance.

INPUTS:

A. Work and living space configurations
B. ACTIVITY AREA VOLUMES (Issue 1010201)
C. CREW CHARACTERISTICS (Issues 1050201, 1050301, 1050401)
D. Crew activities in specific locations
E. MATERIALS & SURFACE CHARACTERISTICS OF SPACE STATION STRUCTURES (Issue 1040001)
F. TRAFFIC FREQUENCY DETERMINATION (Issue 1020101)

CRITICAL ASSUMPTIONS:

None

SPECIAL REMARKS:

(01) Reference (1) provides human factors requirements for effective restraint systems. This document also outlines a restraint design development plan. The present issue resolution plan is based, to a large extent, on this earlier work.

(02) User attitudes towards specific restraint approaches is influenced largely by personal preference. While such user preferences should be satisfied to the greatest extent possible, more objective performance criteria are necessary to resolve objective differences in personal preferences of prospective crew members.

REFERENCES:

(01) Lockheed Engineering & Management Services Company, The Historical Development and Human Factors Evaluative Design Criteria of Intravehicular Crew Restraints and Positioning Devices (by R. Lewis), Contract NAS9-15800, Mar 1985

REPORT FORMAT 14 STUDY PLAN

NUMBER	TITLE	DATE
215M01	IVA CREW RESTRAINTS	05-31-85

STUDY TASKS:

(01) Literature review to establish advantages and limitations of existing IVA crew restraint devices.

(02) Conduct task analyses to determine crew activity parameters in all station locations: duration of tasks, type of body movement, force application, number of crew members involved, rate of movement, body part to be moved or restrained, and devices or tools to be manipulated. Categorize all tasks as either (1) requires only foot restraints, or (2) requires the additional stability of body restraints.

(03) Establish space station design constraints associated with the various crew activity areas: useable volume, surface-to-surface distances, crew traffic patterns, non-standard vs standard reference system, equipment placement, equipment/wall surface characteristics.

(04) Establish performance requirements and design goals for optimal crew restraint devices. Determine anthropometric ranges for relevant body dimensions, e.g., foot size, arm reach. Separately consider foot restraints and body restraints. Body restraints shall consider both passive applications (Figure 1) and active applications requiring extreme stability.

(05) Develop candidate preliminary designs and prototype systems for both foot and body restraints. Differentiate areas where fixed vs portable restraints will be employed. Determine the feasibility of developing a universal restraint and mobility system throughout the station vs task and area specific restraint approaches.

(06) Evaluate the fesability of a restraint concept which permits combining exercise with operations at selected workstations (Figure 2).

(07) Formulate an evaluation program for assessing the effectiveness of candidate existing and new restraint approaches. Define evaluation criteria, e.g., user maneuverability, ease of operation, user autonomy, portability, time factors, fatigue, safety, training, adaptability, user satisfaction, etc.

(08) Evaluate candidate systems utilizing full scale or part task mockups as appropriate in a neutral buoyancy simulator. Select preferred foot and body restraint concepts.

(09) Review with NASA.

(10) Confirm the effectiveness of preferred foot and body restraint approach based on Space Shuttle flight testing.

(11) Develop detailed manufacturing specifications for the selected restraint devices. Develop specifications for integrating restraint systems with the space station design.

SPECIAL STUDY NEEDS:

TASK(S)	NEED
8	Access to space station module and workstation neutral buoyancy mockups and test facilities
10	Access to the Space Shuttle flight test program

SPECIAL SKILLS:

TASK(S)	SKILL
1 - 8	Human Factors Engineer
3,5,7	Crew Systems Designers
4,6,7,8,10	Physiologist
6,7,8,9,10	Astronaut Participation

PERFORMING ORGANIZATION:

(01) Managing: NASA

(02) Doing: Aerospace Firms (Prime)
Crew System Design Firms (Prime)
Human Factors Consulting Groups (Sub)
Prototype Developer (Sub)
Restraint System Manufacturer (Sub)

STUDY PRODUCTS:

Detailed design specifications for:

(01) A foot restraint system for the space station.

(02) A body restraint system for the space station.

(03) A portable restraint system for all potential non-workstation activity areas

(04) Station interface design requirements to accept the recommended restraint systems.

PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS:

SUBELEMENT NO. & TITLE	Undefined Rqmt #
21501 FOOT RESTRAINTS	-02,-06
21502 BODY RESTRAINTS	-05
21505 PORTABLE RESTRAINTS	-01

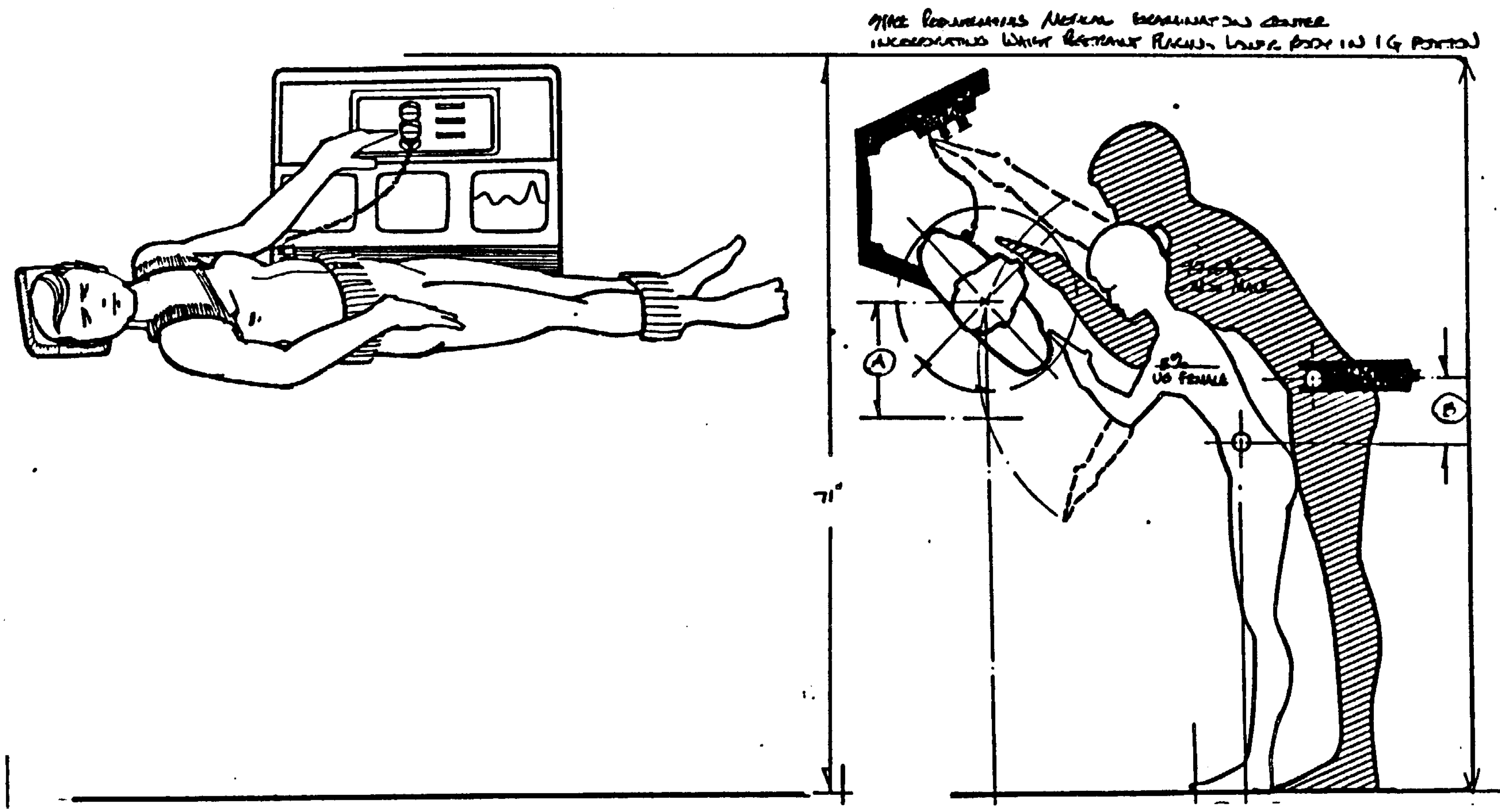

Figure 1. Concept for passive body restraint

215M01

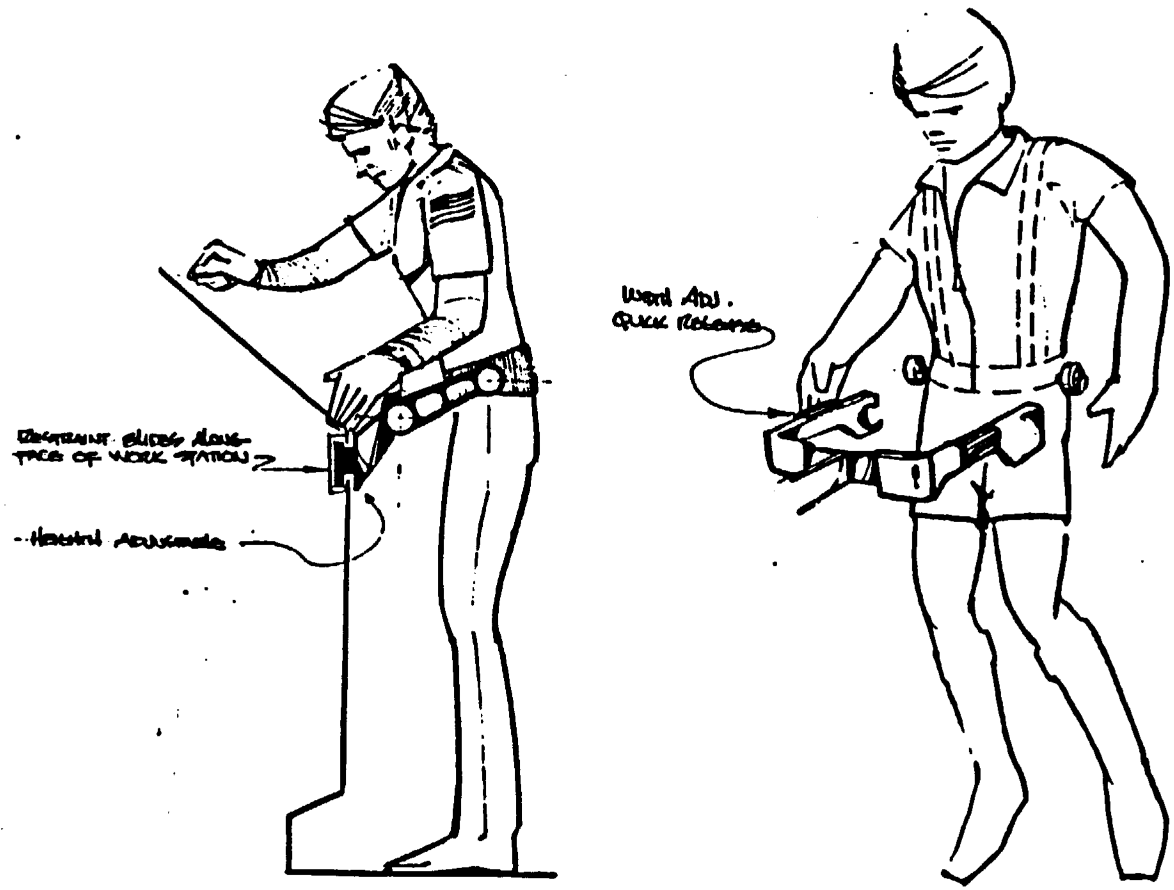

Figure 2. Concept for workstation restraint

215M01

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
215M01	IVA CREW RESTRAINTS	05-31-85

	1985				1986							
CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S
FISCAL	FY 86											
MONTH	1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												
STUDY TASKS												
1. Literature Review	--- 2mm											
2. Task Analysis	C D	----	---- 4mm	----								
3. Space Station Design Constraints					--- 2 mm							
4. Performance, Anthropometric Requirements					A B E F	---- 2 mm	----					
5. Preliminary restraints designs & prototype development								----	---- 16 mm	----		
6. Restraint/exercise feasibility study								----	---- 4 mm	----		
7. Formulate Evaluation Program										--- 2mm		
8. Underwater testing											----	---- 3 mm

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
215M01	IVA CREW RESTRAINTS	05-31-85

	1986			1987								
CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S
FISCAL	FY 87											
MONTH	1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												
STUDY TASKS												
9. NASA review	– .5mm											
10. Space Shuttle flight test		------	------ 6 mm	------	------							
11. Detailed specifications for restraints and SS interface					------ 6 mm	------						

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
215M01	IVA CREW RESTRAINTS	05-31-85

SUMMARY SCHEDULE/COST FACTORS

STUDY SPAN: Oct 85-Mar 87 CM = 18

CATEGORY	FACTOR/MM(CM)*	COST $
LABOR		
- NASA Project Mgmt	TBD	
- Study Mgmt	12.5 MM	
- Study Tasks		
- Analyst, Eng'g		
- Special Skills:	8 MM	
Design Eng'g	19.5 MM	
Human Factors Eng'g	15 MM	
Physiologist	5 MM	
SPECIAL FACILITIES		
- Weightless Environment Training Facility	.25 CM	
- Space Shuttle Flight Test	.25 CM	
TRAVEL		
Coordination w/NASA, Test Facilities, Mfg. Firms		15 K
MATERIALS		
Development of restraint prototypes		85 K
TEST PROGRAM		
OTHER (List)		

* MM = Manmonths; CM = Calendar Months

REPORT FORMAT 13 MANAGEMENT PLAN OVERVIEW

NUMBER	TITLE	DATE
216M01	EQUIPMENT RESTRAINT AND TRANSFER	07-18-85

ISSUE #	TITLE	NEED DATE
2160101	CREW TRANSLATION AIDS	APR 87
2160102	INADVERTENT IMPACT PROTECTION	APR 87
2160201	CONTAINMENT AND TRANSLATION OF EQUIPMENT	APR 87

OBJECTIVES:

(01) Develop comprehensive criteria for crew translation aid requirements for (a) unencumbered crew translation and (b) crew translation when handling parts and equipment.

(02) Develop design criteria for protecting onboard equipment against inadvertent impacts.

(03) Develop design criteria (dimensions, crew aids) for resupply and other equipment items which will be handled by the flight crew.

BACKGROUND:

Operations aboard the space station will involve routine handling of a multitude of items in a variety of situations ranging from site specific activities such as window workstation tasks involving management of numerous small items (e.g., checklists, procedures, cameras, optical sights, film, etc.) to intermodule activities such as transferring and stowing a wide variety of items (e.g., resupply items, spares, maintenance equipment, etc.).

Previous U.S. spaceflight experience with large interior volumes intravehiculea moveable items and transfer distances is a result of the Skylab program, and on a more recent but much more limited basis, the two Shuttle/Spacelab flight. Reported problem areas with equipment handling include:

o Stowage restraints conceal equipment identification marks.

o Book and checklist are aids not available at many use locations, or do not properly consider factors such as lighting, shading, facing angles, print size/eye distance, and relaxed zero-g body position.

o Stowage provisions not designed to restrain remaining items when removing/restowing a specific item.

o Temporary equipment restraints not available at stowage sites, and in general throughout the vehicle.

o Items to be transferred did not have builtin handles or gripping surfaces.

o Damage sensitive items unnecessarily exposed to inadvertant damage from crew or equipment impact.

INPUTS:

A. Work and Living Space Configurations
B. Multi-use versus dedicated space determinations
C. ACTIVITY AREA VOLUMES (Issue 1010201)
D. Crew activities in specific locations
E. TRAFFIC FREQUENCY DETERMINATION (Issue 1020101)
F. INTERIOR DESIGN GUIDELINES (Issue 1030101)
G. NEUTRAL BODY POSTURE DATA DEVELOPMENT (Issue 1050301)
H. STOWAGE CONFIGURATION (Issue 1090101)
I. INTERIOR VOLUME REARRANGEMENT REQUIREMENT (Issue 1060101)
J. Characteristics of resupply items (sizes, shapes, quantities, use locations.)

CRITICAL ASSUMPTIONS:

None

SPECIAL REMARKS:

(01) Flight experience with restraints and translation aids in a situtation analogous to space station is based on a very small population (9 Skylab astronauts). Although this is very valuable experience, it is important to carefully review this experience to identify and evaluate any factors tending to bais the data, and further, to test the design criteria resulting from this study to the extent possible with a larger user population in either manned simulations or shuttle flights prior to committing to space station hardware.

REFERENCES:

(01) None

REPORT FORMAT 14 STUDY PLAN

NUMBER	TITLE	DATE
216M01	EQUIPMENT RESTRAINT AND TRANSFER	07-18-85

STUDY TASKS:

(01) Literature review to establish advantages and disadvantages of existing equipment restraint devices.

(02) Review of Skylab results to identify operational requirements for onboard restraints as a function of specific crew tasks and work location, e.g., operations at window worksties, etc.

(03) Review generic crew activities anticipated on the space station to identify activity types not previously addressed in manned spaceflight.

(04) Perform task analyses for space station era operational activities for which no directly relevant experience exists, e.g., resupply item deployment throughout the station, activities such as laundering clothes, etc., to characterize equipment restraint and translation aid requirements.

(05) Establish performance requirements and design goals for:
(a) Equipment restraint devices
(b) Crew translation aids.

(06) Establish space station design constraints associated with the crew activity areas: useable volume, surface-to-surface distances, crew traffic patterns, equipment placement, equipment/wall surface characteristics, moveable versus permanent surfaces, characteristics of supplies and equipment items requiring temporary restraints, etc.

(07) Select a set of candidate equipment restraints for application to space station. The set is to include those designs which performed satisfactorily on Skylab, Spacelab, and other manned missions, as well as new concepts which appear to satisfy the space station requirements as identified in tasks 1-6.

(08) Formulate an evaluation program for assessing the effectiveness and operational suitability of the candidate restraints. Define evaluation criteria. Consider the spectrum of restrain applications required in the station.

(09) Evaluate candidate equipment restraints using part-task or complete fullscale mockups as appropriate. The evaluation process to include neutral buoyancy and/or zero-g atmospheric flight tests.

(10) Confirm the results of the evaluation process by further evaluating the recommended restraint concept(s) on selected shuttle missions.

(11) Formulate a comprehensive set of restraint system design guidelines for the space station program.

(12) Develop candidate translation aid concepts for the various habitability and workstation activity areas in the space station. Consider combinations of handrails, handholds, gripping surfaces, pushoffs, etc., as appropriate. Review with astronauts with extensive zero-g time.

(13) Formulate a program to evaluate the preferred translation aid systems identified by task 12. Evaluate under neutral buoyancy conditions, considering both personal translation and representative equipment item transfer.

(14) Formulate translation aid guidelines for the space station program.

(15) Utilizing the configuration, logistics, crew activity, and related data gathered during the performance of the above subtasks, plus the guidelines developed in task 13, formulate a set of design guidelines to minimize the risk of equipment damage by inadvertent impacts.

SPECIAL STUDY NEEDS:

TASK(S)	NEED
9,13	Access to space station module and workstation neutral buoyancy mockups & test facilities
9	Potential requirement for access to NASA KC-135 zero-g aircraft
10	Access to space shuttle flights
12	Access to astronauts with extensive zero-g time

SPECIAL SKILLS:

TASK(S)	SKILL
1 - 9	Crew Systems or Human Factors Engineer
10	Astronaut
11 - 15	Crew Systems or Human Factors Engineer

PERFORMING ORGANIZATION:

(01) Managing: NASA Laboratories

(02) Doing: Aerospace Firms (Prime)
Crew Systems Design Firms (Prime)
Human Factors/Manned Systems Consulting Groups (Sub)
Prototype Developer (Sub)
Flight Hardware Manufacturer (Sub)

STUDY PRODUCTS:

Detailed design specifications for:

(01) IVA equipment restraint system for the Space Station Program.

(02) IVA Translation Aid Design Guidelines for the Space Station Program.

(03) Inadvertent Impact Risk Reduction Design Guidelines for the Space Station Program.

PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS:

SUBELEMENT NO. & TITLE	Undefined Rqmt #
21601 INSTALLED EQUIPMENT	-03,-04
21602 PORTABLE GEAR	-04

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
216M01	EQUIPMENT RESTRAINT AND TRANSFER	07-18-85

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                                      1985      |   1986                    |
                             CALENDAR|O--N--D--|J--F--M--A--M--J--J--A--S--|
                               FISCAL|FY 86                                |
                                MONTH|1  2  3   4  5  6  7  8  9  10 11 12 |
                              PHASE B|                                     |
                                    C|                                     |
STUDY  TASKS                         |                                     |
1. Literature Review                 |------                               |
                                     | 2 mm                                |
2. Review Skylab results             |   ----                              |
                                     |   1 mm                              |
3. Review Generic Crew Activities    |       -----                         |
                                     |       1 mm                          |
4. Perform Task Analysis             |           --------                  |
                                     |             2 mm                    |
5. Establish performance requirements|                   -------           |
   & design goals                    |                     3 mm            |
                                     |                                     |
6. Establish Space Station design    |                   -------           |
   constraints.                      |                     3 mm            |
                                     |                                     |
7. Select candidate equipment        |                          ------------|
   restraints                        |                              8 mm   |
                                     |                                     |
8. Formulate evaluation program,     |                                ------|
   equipment                         |                                 2 mm|
                                     |                                     |
12. Select, develop candidate        |                          ------------|
    translation aids                 |                              6 mm   |
                                     |                                     |
13. Formulate evaluation program,    |                                ------|
    translation aids and evaluate.   |                                 2 mm|
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REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
216M01	EQUIPMENT RESTRAINT AND TRANSFER	07-18-85

	1986			1987								
CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S
FISCAL	FY 87											
MONTH	1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												
STUDY TASKS												
9. Evaluate candidate equipment restraints using simulation	6 mm											
10. Evaluate on STS if possible				2 mm								
11. Formulate guidelines, equipment					2 mm							
13. (cont)	4 mm											
14. Formulate translation aid guidelines					2 mm							
15. Based on Task 1-14, formulate equipment and translation aid design guideline, if needed							2 mm					

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
216M01	EQUIPMENT RESTRAINT AND TRANSFER	07-18-85

SUMMARY SCHEDULE/COST FACTORS

STUDY SPAN: Oct 85-Jun 87 CM = 20

CATEGORY	FACTOR/MM(CM)*	COST $
LABOR		
- NASA Project Mgmt	10 MM	
- Study Mgmt		
- Study Tasks		
- Analyst, Eng'g	14 MM	
- Special Skills:		
Crew Systems Eng.	14 MM	
Human Factors Eng.	14 MM	
Astronaut	6 MM	
SPECIAL FACILITIES		
Neutral buoyancy mock-up	1 wk	
NASA KC-135	8 hrs	
TRAVEL		
Coordination		15 K
MATERIALS		
None		
TEST PROGRAM		
STS Flight	8 hrs	
OTHER (List)		
None		

* MM = Manmonths; CM = Calendar Months

REPORT FORMAT 13 MANAGEMENT PLAN OVERVIEW

NUMBER	TITLE	DATE
218M01	ON-ORBIT CONFIGURATION MODS VERIFICATION	07-19-85

ISSUE #	TITLE	NEED DATE
2180601	ON ORBIT CONFIGURATION MODS VERIFICATION	APR 89

OBJECTIVES:

(01) Determine the depth and degree of data reporting necessary to maintain cognizance of the real-time operational configuration of the Space Station and associated systems during the life of the Space Station Program.

(02) Develop the detailed requirements to be imposed on Space Station on-orbit personnel for recording changes to equipment and systems configurations, including both hardware and software.

(03) Determine the most effective and efficient method for providing Configuration Modification Verification (CMV) reports.

(04) Determine satisfactory formats for making CMV reports.

(05) Determine the appropriate relationships between CMV reports and other possible records such as discrepancy, logistics, and maintenance scheduling and status reports.

(06) Determine the data storage requirements for CMV reporting.

BACKGROUND:

The ability to operate the Space Station system effectively will require close attention to system modifications made during the total life on orbit. A planned approach to specific reporting of changes will be necessary. The approach should be integrated with other types of reporting (maintenance status, growth change status, failure reporting, etc.), but should specify a format with well defined data elements. Early data element identification is required to allow reporting to start with the first manned Space Station mission.

Formal, real time, configuration modification reporting was not used for earlier spacecraft systems. The relatively simple systems, continuous ground monitoring, short lifetime, small crews, break between missions, and time available for crew training allowed this omission. On Skylab several changes of minor and major significance occurred, affecting both operational and payload systems. The configuration definition could still be maintained through crew-to-ground communication and crew debriefings. Training between missions was extended, if necessary, to acquaint the next mission crew with the configuration changes.

On Space Station the need for a tightly controlled system for verifying modifications to the configuration is indicated. This conclusion is drawn because of the crew rotation timing, long program

life, autonomy of operations, system complexity, and crew size and specialization. The reporting system should account for actual versus planned changes, and include unplanned events, whether they result from crew action (workarounds), accidents, equipment wear or age, or other causes.

INPUTS:

A. configuration control system to be used during design, fabrication, assembly, test, and operation of the Space Station complex.
B. Details of the systems to be used, if any, for discrepancy (Management Plan 214M03) reporting (Management Plan 218M09), logistics status display, maintenance scheduling and status records, etc.
C. Descriptive data and configuration accounting systems in use in commercial airline operations.
D. Orbiter operational configuration contrl system description.
E. Management Communication and Data Storage (MCDS) system definition.
F. Space Station subsystems definitions.

CRITICAL ASSUMPTIONS:

(01) Crew rotation will occur without periods of non-habitation of the Space Station (i.e., operations handover will occur on orbit).

(02) Operations crews will be responsible for all hardware systems modifications (i.e., there will be no missions designed to maintain or refurbish equipment, or status system configuration).

(03) Changes to the software configuration can be implemented by flight crew personnel.

(04) The operation of the Space Station orbiting system will be autonomous, or nearly autonomous, after the early missions.

(05) The flight crew will have the necessary knowledge, skill, information, tools and equipment, and opportunity to make planned and unplanned changes to the Space Station hardware configuration during active mission phases.

(06) Resolution of this issue will have no effect on Space Station system hardware and minimal effect on the data storage and retreival system.

(07) The schedule start date assumes completion of system requirements definintion in mid-1986.

SPECIAL REMARKS:

(01) Reports verifying the occurence of configuration changes or modifications may be made directly or be derived from other reports such as failure reports. The essence of the report will be an identification of the details of system changes at the time they occur.

(02) The schedule established for resolution of this issue was based on the need for report system definition to allow estimating the total data storage requirements for the Space Station data processing system.

(03) Commercial airline methods of maintaining a record of the operational configuration of individual aircraft, and the system in use at KSC to maintain the Space Transportation System Orbiter vehicle configuration appear most closely related to the conditions described in this plan.

(04) Manloading for this study is predicated on adapting commercial airline techniques as amended by the approach used for the orbiter at NASA-KSC, (i.e., the approach will not be derived from scratch).

<u>REFERENCES</u>:

None

REPORT FORMAT 14 STUDY PLAN

NUMBER	TITLE	DATE
218M01	ON-ORBIT CONFIGURATION MODS VERIFICATION	07-19-85

STUDY TASKS:

(01) System Analysis. Perform system analysis to determine the type of configuration verification data required and the detail necessary to provide the capability to operate the Space Station system safely and effectively during the total life of the program, to recover at any time from contingencies, and to plan future desired system configuration modifications. This task requires an understanding of the total Space Station orbiting system design and the system operations plans.

(02) Airline Overview. Consult with one or more commercial airline firms (United and Continental Airlines are suggested) to get an overview of the system in use by those organizations to maintain a real time record of the engineering and operational configuration of individual aircraft while in service, and to update the configuration records during periodic inspection, overhaul, and maintenance activities.

(03) KSC Overview. Review the system in use at KSC to maintain the configuration record of the Orbiter flight vehicles, including integration of the configuration changes made as a result of crew action or equipment anomalies that occur during a mission.

(04) Determine Applicability. Determine whether CMV reporting should be made applicable to all elements of the Space Station System (operational, experimental, production, and co-orbiting equipment) or be limited to operational equipment. Also determine whether the reporting should be uniform in detail and rigor for non-critical as well as critical sub-systems. Completion of this task will require coordination with all appropriate Space Station Program organizational elements.

(05) Data Element Definition. Develop CMV report data element definitions (i.e., the data fields for the reports and definitions of the data to be entered in those fields) and coordinate with configuration management, engineering, and operations organizations to obtain agreement that the data is reasonably available and adequate in detail.

(06) Format Development. Develop report format(s) which account for the data entries to be made by the flight crew, those to be made by ground personnel, or generated by computer. The format developed should recognize the potential use of the reports for configuration definition updates by electronic processes, and the derivation of data elements from quality assurance, configuration definition, or other records that are to be maintained.

(07) Procedues Development. Develop the flight and ground operations procedures to be used in completing the CMV reports. Include consideration of the necessity for:
a. Hardcopy of records.

b. The application of audio or video recording to CMV reporting, with direct or delayed transmission to ground stations for ground crew development of detailed CMV reports.

c. The use of direct keyboard entry for reporting.

(08) Data Processing Estimate. Assess the application of the CMV reporting system to the Space Station system to estimate the hard copy and computer systems data storage and processing requirements.

SPECIAL STUDY NEEDS:

TASK(S)	NEED
	None identified.

SPECIAL SKILLS:

TASK(S)	SKILL
	None identified.

PERFORMING ORGANIZATION:

(01) Managing: NASA Level B, JSC Quality Assurance organization

(02) Doing: Aerospace contractor (Prime)
Systems engineering organization (Sub)

STUDY PRODUCTS:

On-orbit CMV Report Format.

Procedures to be followed by flight and ground crews in performing the reporting of the completion of planned and contingency Space Station system configuration changes, or of changes to the configuration that occur because of hardware or software problems.

PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS:

SUBELEMENT NO. & TITLE	Undefined Rqmt #
21806 REPORTING AND RECORDING	-02

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
218M01	ON-ORBIT CONFIGURATION MODS VERIFICATION	07-19-85

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                                      1986       |   1987                              |
                            CALENDAR|O--N--D--|J--F--M--A--M--J--J--A--S|
                              FISCAL|FY 87                                             |
                               MONTH|1  2  3   4  5  6  7  8  9 10 11 12|
                             PHASE B|                                                  |
                                   C|                                                  |
STUDY  TASKS                        |                                                  |
                                    |A                                                 |
                                    |B                                                 |
                                    |F                                                 |
1. System Analysis                  |-----------                                       |
                                    |  (1 mm)                                          |
2. Airline Overview                 |  C-------------                                  |
                                    |      (.25 mm)                                    |
3. KSC Overview                     |  D-------------                                  |
                                    |    (.25 mm)                                      |
4. Determine Applicability          |             ----------------------|
                                    |                     (.5 mm)                      |
5. Data Element Definition          |            E----------------------|
                                    |                      (1 mm)                      |
```

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
218M01	ON-ORBIT CONFIGURATION MODS VERIFICATION	07-19-85

	1987			1988								
CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S
FISCAL	FY 88											
MONTH	1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												
STUDY TASKS												
6. Format Development	---	---	---	---	---	---	---	---	---	---	---	---
					(1 mm)							
7. Procedures Developemnt	---	---	---	---	---	---	---	---	---	---	---	---
					(2 mm)							
8. Data Processing Estimate			---	---	---	---	---	---				
					(.5 mm)							

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
218M01	ON-ORBIT CONFIGURATION MODS VERIFICATION	07-19-85

SUMMARY SCHEDULE/COST FACTORS

STUDY SPAN: OCT 86-OCT 88 CM = 24

CATEGORY	FACTOR/MM(CM)*	COST $
LABOR		
- NASA Project Mgmt	2 MM	
- Study Mgmt	.25 MM	
- Study Tasks		
- Analyst, Eng'g	6.25 MM	
- Special Skills:		
SPECIAL FACILITIES		
No Reqmt. identified		
TRAVEL		
Coordinatioin with NASA on study		1 K
Coordination with KSC		2 K
Coordination with Commercial Airlines		2 K
MATERIALS		
TEST PROGRAM		
OTHER (List)		

* MM = Manmonths; CM = Calendar Months

REPORT FORMAT 13 MANAGEMENT PLAN OVERVIEW

NUMBER	TITLE	DATE
218M02	ON-ORBIT PROBLEM REPORTING SYSTEM	6-22-85

ISSUE #	TITLE	NEED DATE
2180501	ON-ORBIT PROBLEM REPORTING SYSTEM	APR 89

OBJECTIVES:

(01) Develop detailed requirements for the reporting, recording, and resolution of hardware and software problems (failures and unsatisfactory conditions) that occur after the Space Station Program elements are placed in orbit.

(02) Prepare appropriate directives, mission rules, and other instructions and coordinate necessary NASA management approval leading to implementation of a closed loop system of problem reporting and resolution.

BACKGROUND:

A closed loop system for problem reporting and analysis, determination of corrective action, and implementation of positive recurrence control has long been a requirement for NASA manned spaceflight programs. The data reporting requirements, data storage and retrieval system, analysis and corrective action determination techniques, and organizational structure necessary for effective operation of the system are well defined. The requirement for successful application of the system to the Space Station operational and ancillary equipment during on-orbit operations is to properly tailor the elements of the system to the nature of the program. In particular, cognizance must be taken of:

o While equipment which exhibits problems may eventually be returned to earth for failure analysis, determination of corrective action in time for the next launch will require detailed problem reports from the flight crew,

o Equipment changes necessary to effect recurrence control must be implemented by the on-orbit crews.

Space Station Program POP (Program Operations Plan) 488-40, Space Station On-orbit Problem Reporting and Corrective Action System, has been initiated to accomplish the necessary research and coordination to resolve this issue.

INPUTS:

A. Not applicable

CRITICAL ASSUMPTIONS:

(01) Space Station Program POP 488-40, Space Station On-Orbit Problem and Corrective Action System, will be funded and the work described in the POP completed in time to support the identified need date.

SPECIAL REMARKS:

(01) This issue will be closed by completion of the activities defined in Space Station POP 488-40.

(02) Resolution of this issue will permit completion of requirements 21805-01, -02, and -03 which were defined for Subelement 21805, Anomaly Investigation, Analysis, and Evaluation.

REFERENCES:

(01) None

REPORT FORMAT 13 MANAGEMENT PLAN OVERVIEW

NUMBER	TITLE	DATE
218M03	FLUID SYSTEM CONNECTION INTEGRITY VERIFICATION	6-27-85

ISSUE #	TITLE	NEED DATE
2180301	ON-ORBIT FLUID SYS CONTAMINATION CONTROL	JAN 88

OBJECTIVES:

(01) Determine the method(s) to be employed to verify the integrity of fluid connections made on-orbit.

(02) Establish system design requirements to permit fluid connection verification.

(03) Prepare detailed specifications for in-flight fluid connection verification support equipment.

(04) Determine flight crew procedures for fluid connection integrity verification.

BACKGROUND:

Because of the planned evolutionary growth of the Space Station, with final assembly, integration, and demonstration performed on orbit, a number of fluid systems connections will be required. Similarly, there will be continuing need for fluid system connections and disconnection requirements for: 1) incorporating advanced technology subsystems as they become available, 2) repair by replacement of components to the orbital replacement unit level, and 3) servicing the Space Station free flyers and upper stages.

Stringent requirements for control of contamination, both inside the habitable environment and outside, and for minimizing fluid losses, suggest that there is a requirement for the capability to verify the integrity of fluid line connections before introduction of the contained liquid into the affected part of the system. The verification method itself should not contribute to environmental contamination.

The present issue resolution management plan provides a technical approach for developing fluid system connection verification requirements and fluid systems design features required to support the verification methods. It also addresses development of support equipment requirements and procedures in support of Management Plan Equipment, and 218M05, QA On-orbit Verification Requirements.

INPUTS:

A. FLUID SYSTEMS CONFIGURATIONS
  1. INSIDE
    a. COOLANT SYSTEMS
    b. LIFE SUPPORT SYSTEMS

c. WATER SYSTEMS
d. PROCESS AND EXPERIMENT SYSTEMS
e. OTHER
2. OUTSIDE
a. PROPELLANTS/FUELS
b. COOLANTS
c. OTHER

B. FLUID MEDIUMS
C. SYSTEM WORKING PRESSURES
D. SYSTEM VOLUMES
E. ENVIRONMENTAL CONTAMINATION LIMITS
-INSIDE
-OUTSIDE
F. ENVIRONMENTAL CONTAMINATION DETECTION SYSTEMS CONFIGURATION AND CAPABILITY
-INSIDE
-OUTSIDE

CRITICAL ASSUMPTIONS:

(01) Major assemblies will be proof and leak checked on the ground. This study will apply only to connections made on orbit.

(02) Fluid connections made on orbit may include 1) manual connections made by crewmembers inside or outside the habitable environment, and 2) remote, automatic or semi-automatic connections outside the habitable environment, such as umbilical connections for refueling operations. In either case, connection integrity should be verified.

(03) Study task scheduling is based on ISR date of June 86 and a PDR date of Jan 88.

SPECIAL REMARKS:

(01) This study is limited to verification of fluid system connections made on orbit. It is assumed that all other connections will be verified on the ground.

(02) This study must take into account that an EMU-suited crewmember may be making repairs to the ECLSS after an anomalous event.

(03) Support equipment requirements and verification procedures will support Management Plan 218M05, QA On-orbit Verification Requirements.

(04) Verification methods and procedures might be verified during planned shuttle reservicing operations or as special experiments.

(05) In order to meet Space Station schedule requirements, initial system design specifications for features required to verify fluid connections should be based on the Space Station reference configuration description, JSC 19989. Specifications should be broad enough to accommodate possible changes in the reference configuration, as well as changes required as a result of testing and shuttle on-orbit experimentation.

(06) The first of three cryogenic fluid management facility shuttle flights to study handling of cryogenic fluids in space is scheduled for late 1987.

(07) References 01 - 06 should be reviewed and analyzed during the execution of this study.

REFERENCES:

(01) Space Station Technology 1983, NASA Conference Publication 2293, 1984

(02) Certification and Recertification of Ground Based Pressure Vessels and Pressurized Systems, JSCM 1710, May 1977

(03) Space Shuttle On-orbit Refueling System Test and Operational Results, STS 41G, Oct 1984

(04) Rockwell International Specification MF 0001-003, Rev. K, Proof Pressure and Leak Detection-Aerospace Plumbing Systems and Assemblies, Feb. 17, 1975

(05) Minutes of Coolanol Reservicing System Critical Design Review, NASA JSC Memorandum KA-JSC-73-79, Aug 21, 1973

(06) Leakage Testing Handbook, Liquid Propulsion Section, Jet Propulsion Laboratory, S-69-1117, July 1969

NUMBER	TITLE	DATE
218M03	FLUID SYSTEM CONNECTION INTEGRITY VERIFICATION	6-27-85

STUDY TASKS:

(01) Gather Fluid Systems Configuration Data - Gather data from Space Station definition efforts to establish fluid systems configurations.

(02) Literature Review - Review literature to establish capabilities and limitations of current leak detection techniques.

(03) Determine Criteria and Requirements - Determine by analysis, criteria and requirements necessary to verify fluid line connection integrity. Take into account that an EMU-suited crewmember may have to perform these operations.

(04) Determine Leakage Effects - Determine effects of worst-case leak check fluid leakage on Space Station environments.

(05) Develop Candidate Methods - Develop candidate leak detection methods for the various fluid systems, taking into account the compatability of the leak check medium or method with the system fluid.

(06) Formulate Design Specifications - Formulate specifications for Space Station fluid systems and for the in-flight support equipment required to implement selected verification methods.

(07) Build Mockups - Prepare full-scale mockups for determination of suitability of verification methods.

(08) Build Flight Experiments - Build experiment packages for shuttle on-orbit experiments as required to confirm procedures.

(09) Develop Flight Crew Procedures - Develop procedures to verify fluid connection integrity on orbit.

SPECIAL STUDY NEEDS:

TASK(S)	NEED
1	Space Station fluids systems configuration data and operating parameters.
5	Space Station environmental contamination limitations.
6	Access to full scale Space Station and fluid systems mockups.
7	Shuttle on-orbit experimentation capability

SPECIAL SKILLS:

TASK(S)	SKILL

1 ¦Model making capability
¦

PERFORMING ORGANIZATION:

(01) Managing: NASA, Level C

(02) Doing: NASA Laboratories
Aerospace Contractors

STUDY PRODUCTS:

Specific methods to be employed to verify the integrity of fluid connections made on-orbit.

Design specifications for fluid systems and in-flight support equipment required to support the proposed verification methods.

Crew procedures for in-flight fluid line connection verification.

PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS:

SUBELEMENT NO. & TITLE	Undefined Rqmt #
21803 Contro	-05
*21802 Condition Verification	-01a,-01c

*Partial contribution to undefined requirement completion

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
218M03	FLUID SYSTEM CONNECTION INTEGRITY VERIFICATION	6-27-85

```
                                         1985      |    1986                           |
                                 CALENDAR|O--N--D--|J--F--M--A--M--J--J--A--S|
                                   FISCAL|FY 86                              |
                                    MONTH|1  2  3   4  5  6  7  8  9 10 11 12|
                                  PHASE B|                                   |
                                        C|                                   |
STUDY  TASKS                             |                                   |
Assuming ISR June 86 & PDR Jan 88        |A,B,C,D,E,F                        |
1. Gather Configuration Data             |^---
                                         |(1m/m)                             |
2. Literature Review                     |---                                |
                                         |(1m/m)                             |
3. Determine Criteria and Reqmts.        |   ---                             |
                                         |  (1m/m)                           |
4. Determine Leakage Effects             |      ---                          |
                                         |     (1m/m)                        |
5. Develop Candidate Methods             |      ----------------             |
                                         |         (3m/m)                    |
6. Formulate Design Specs                |                   ------------    |
                                         |                      (4m/m)       |
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REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
218M03	FLUID SYSTEM CONNECTION INTEGRITY VERIFICATION	6-27-85

	1986			1987								
CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S
FISCAL	FY 87											
MONTH	1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												
STUDY TASKS												
7. Build Mockups	----- (4m/m)	-----	-----	-----								
8. Build Experiments					-----	-----	-----	-----	----- (8m/m)	-----	-----	-----

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
218M03	FLUID SYSTEM CONNECTION INTEGRITY VERIFICATION	6-27-85

	1987			1988								
CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S
FISCAL	FY 88											
MONTH	1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												
STUDY TASKS												
9. Develop Crew Procedures	----------- (4m/m)											

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
218M03	FLUID SYSTEM CONNECTION INTEGRITY VERIFICATION	6-27-85

SUMMARY SCHEDULE/COST FACTORS

STUDY SPAN: Oct 85 Dec 88 CM =28

CATEGORY	FACTOR/MM(CM)*	COST $
LABOR		
- NASA Project Mgmt		
- Study Mgmt	16.0 mm	
- Study Tasks		
- Analyst, Eng'g	23.0 mm	
- Special Skills:		
- Model Maker	4.0 mm	
SPECIAL FACILITIES		
-IG SS Simulator	4.0 cm	
TRAVEL		
-Coordinate w/NASA, Aerospace Co's		15K
MATERIALS		
-Mockup Fabrication		20K
TEST PROGRAM		
-On-orbit Testing Costs		GFE
OTHER (List)		

* MM = Manmonths; CM = Calendar Months

NUMBER	TITLE	DATE
218M04	HABITABLE VOLUME LEAK POINT LOCATION	6-27-85

ISSUE #	TITLE	NEED DATE
218087	HABITABLE VOLUME LEAK POINT LOCATION	AUG 88

OBJECTIVES:

(01) Identify method for determining the location of a leak in the pressure membrane or the sealing surfaces of the Space Station.

(02) Identify Space Station system design requirements to facilitate location of a leak.

(03) Identify design requirements for equipment to locate a leak.

(04) Construct and demonstrate leak locating equipment.

(05) Develop procedures for use of the leakage location equipment.

BACKGROUND:

During the lifetime of the Space Station program it is anticipated that the pressurized volumes will develop leaks. Obviously, it is highly desirable to be able to locate and repair these leaks.

The United States space program began development of leakage location techniques as a part of the Skylab program. Leakage location devices were developed by Martin Marietta and McDonnell Douglas Corporation for potential use on Skylab. Development progressed to the point of demonstration of the efficiency of these devices on a test board. Development efforts were terminated on the basis of device operational difficulties by the crew and inaccessibility of a large percentage of potential Skylab leakage paths.

The present issue resolution management plan provides an approach for development of leakage location equipment for the Space Station. It considers what system design requirements and support equipment would be required to allow location of the leak. It also requires that the detection technique pose no additional hazards to the crew or spacecraft.

INPUTS:

A. PRESSURIZED CABIN VOLUME
B. SOLID VOLUME OF ITEMS IN THE PRESSURIZED VOLUME
C. SIZE AND LOCATION OF PRESSURIZED VOLUME SEALS
D. LAYOUT OF PRESSURIZED VOLUME EQUIPMENT INSTALLATIONS IN RELATIONSHIP TO SPACECRAFT PRESSURE MEMBRANES
E. ANTICIPATED AMOUNT OF ATMOSPHERIC CONSTITUENT CONSUMABLES AND AMOUNT ALLOWABLE TO LEAKAGE
F. CONTINGENCY MAKE-UP CAPABILITY OF PRESSURE CONTROL SYSTEM

G. WEIGHT AND VOLUME CONSTRAINTS ON LEAKAGE LOCATING DEVICES
H. SPACE STATION SYSTEMS DESIGN REQUIREMENTS AND CONFIGURATION

CRITICAL ASSUMPTIONS:

(01) Three classifications of leakage are to be considered by the Issue. These classifications are as follows:
a. Nuisance Leakage - this class of leakage proceeds at a low rate, does not significantly increase with time, and is within the normal make-up capability of consumables and spacecraft system design.
b. Critical Leakage - this class of leakage proceeds at a rate which exceeds make-up capability, but allows a finite period of time before the volume becomes uninhabitable to shirt sleeved crew members.
c. Gross Leakage - this class of leakage greatly exceeds make up capability and requires rapid isolation of the affected volume for crew safety.
The primary areas of interest by this study are critical leakages.

(02) Zero-gravity and vacuum environment verification will be required.

(03) Crew related activities may be interrupted to allow for critical leakage location activities.

(04) Pressure membrane walls and seals associated with habitable volumes will be accessible to both shirt sleeved and EMU-suited crewmembers.

(05) Membrane damage to one habitable module will not propogate to adjacent modules.

(06) Schedule based on identification of Space Station design requirements to support ISR in June 1986.

SPECIAL REMARKS:

(01) Leakage repair techniques will not be addressed by this investigation.

(02) Techniques to detect that excess spacecraft atmosphere pressure loss is occurring will not be addressed by this investigation.

(03) Techniques for isolation of the affected volume from the remaining portions of the spacecraft, if necessary, will not be addressed by this investigation.

(04) The technique design will not create additional hazards to the Space Station.

(05) Leakage point location technique will provide an input to Management Plan 303M01, Wall Access/Repair.

(06) Refer to References 01-09 during the execution of this study.

(07) Minimizing the crew workload is a primary consideration in the selection of equipment and procedures.

REFERENCES:

(01) NASA Solicitation #9-BF-10-4-01P, "Space Station Definition and Preliminary Design, Request for Proposal", September 84.

(02) NASA Case No. NPO-15,790-1, Portable Laser Remote System for Methane Gas Detection

(03) Leak Detector Review Boeing-Houston Technical Information Release 5-2630-397, Sep 14, 1972.

(04) Operations OCR Action Item-habitation Area Leak Detection and Repair, Boeing-Houston Technical Information Release 5-2630-HOU-531. Jan. 25, 1973

(05) Leakage Testing Handbook, Contract NAS 7-396, General Electric for Jet Propulsion Laboratory, July 1969.

(06) Portable Leak Detection Thermistor Type, McDonnell Douglas Presendation, July 1972

(07) Program Plan, Study of Damage Control Systems, McDonnell Douglas, Dated July 1972

(08) Nondestructive Equipment Study, TRW Space and Technology Group, DRL No. RA509T, Contract NAS9-17101, January 25, 1985.

(09) Identification of Leaks-Internal Acoustic Technique, Final Report, Institute of Gas Technology, Report No. GRI 80/0143, Nov 1980-Jan 1982.

REPORT FORMAT 14 STUDY PLAN

NUMBER	TITLE	DATE
218M04	HABITABLE VOLUME LEAK POINT LOCATION	6-27-85

STUDY TASKS:

(01) Define Leak Rate Limits - Define leakage rate limits for nuisance, critical, and gross leaks.

(02) Perform Literature Search - Perform literature search to identify techniques for Space Station leakage location. Areas of potential investigation include: Skylab experience with leakage isolation, holography or other laser related techniques, ultrasonic flaw detection devices, dye penetrant inspection type devices, trace gases/radioactive particles (viewed internally/externally), sound or sonic type devices, and visual.

(03) Evaluate and Select Candidates - Evaluate and select potential leakage locating techniques. Techniques will be based upon station design and safety requirements, including the ability to detect leakage location and to isolate an affected volume. Techniques must be capable of being performed by an EMU-suited crewmember. Leakage locating schemes which can isolate nuisance and critical leakage should be given high priority. The schemes must be compatible with the overall design concepts and environment of the Space Station.

(04) Establish Space Station Requirements - Establish Space Station systems design requirements to facilitate location of a leak. These requirements will have been identified during the literature search and evaluation tasks. The identified Space Station design requirements will be documented and considered by NASA for incorporation into the Space Station overall design.

(05) Analyze Leak Detection Techniques - Analyze/test the techniques which offer the greatest leakage detection capability. This task will provide data for selection of a leakage isolation technique for continued development.

(06) Select Promising Leak Detection Technique - Select the preferred technique(s) for continued evaluation and development. Criteria to be used in the selection process should include: accuracy of the leakage location device, estimated weight and volume penalty associated with the techniques, rapidity with which the technique may be used by the crew, impact of the technique on habitability of the pressurized volumes of the spacecraft, potential hazards introduced by the technique, reliability of the technique, impact of speed of implementation on consumables, and compatibility with Space Station pressure membrane accessibility characteristics.

(07) Design and Construct Test Equipment - Design and construct leakage location equipment for zero-gravity and vacuum environment evaluation.

(08) Evaluate Leak Detection Candidates - Evaluate leakage locating techniques in zero-gravity and vacuum environment.

(09) Develop Procedures - Develop procedures to store, operate, and maintain the leakage location equipment. These procedures will be used for zero-gravity and vacuum environment demonstrations.

(10) Prepare Final Report - Produce and release a final report to document study and development results. This report will include the identification of usage restrictions for the leakage locating equipment and recommendations for follow on activities.

SPECIAL STUDY NEEDS:

TASK(S)	NEED
6	Astronaut evaluation
6	Space Station mock-up
9	Zero-gravity and vacuum environment

SPECIAL SKILLS:

TASK(S)	SKILL
	None

PERFORMING ORGANIZATION:

(01) Managing: NASA-JSC, SR-QA Division
Doing: Aerospace Firms (Prime)
Industrial Design Firms (Sub)

STUDY PRODUCTS:

(01) Documentation of the leakage isolation equipment and procedure scheme selection.

(02) Space Station design criteria which facilitates the selected leakage detection scheme.

(03) Leakage locating equipment, engineering drawings, and specifications.

(04) Documented demonstration results of leakage location equipment.

(05) Procedures for use, operation, and maintenance of leakage location equipment.

PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS:

SUBELEMENT NO. & TITLE	Undefined Rqmt #
21807 Detection, Isolation and Identification	-01

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
218M04	HABITABLE VOLUME LEAK POINT LOCATION	6-27-85

```
                                           1985        |    1986                                 |
                                   CALENDAR|O--N--D--|J--F--M--A--M--J--J--A--S--|
                                     FISCAL|FY 86                                            |
                                      MONTH|1  2  3    4  5  6  7  8  9  10 11 12|
                                    PHASE B|                                                 |
                                          C|                                                 |
STUDY  TASKS                               |                                                 |
Assuming SDR in Dec. 1986                  |A,B,C,D,E,F,G,H                                  |
1. Define Leak Rate Limits                 |------^                                          |
                                           |(1m/m)                                           |
2. Perform Literature Search               |-----------                                      |
                                           | (4m/m)                                          |
3. Evaluate and Select Candidates          |           ------------------                    |
                                           |                (6m/m)                           |
4. Establish Space Station Require-        |                              -------            |
   ments                                   |                              (2m/m)             |
5. Analyze Leak Detection Techniques       |                                   -----------|
                                           |                                                 |
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REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
218M04	HABITABLE VOLUME LEAK POINT LOCATION	6-27-85

	1986			1987								
CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S
FISCAL	FY 87											
MONTH	1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												

STUDY TASKS	Schedule
1.	
2.	
3.	
4.	
5. Analyze Leak Detection Techniques	---------------------------- (12m/m)
6. Select Promising Leak Detection Techniques	--- (2m/m)
7. Design and Construct Test Equipment	------

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
218M04	HABITABLE VOLUME LEAK POINT LOCATION	6-27-85

```
                                         1987        |     1988                              |
                                 CALENDAR|O--N--D--|J--F--M--A--M--J--J--A--S--|
                                   FISCAL|FY 88                                |
                                    MONTH|1  2  3   4  5  6  7  8  9  10 11 12 |
                                  PHASE B|                                     |
                                        C|                                     |
STUDY  TASKS                             |                                     |
                                         |                                     |
1.                                       |                                     |
                                         |                                     |
2.                                       |                                     |
                                         |                                     |
3.                                       |                                     |
                                         |                                     |
4.                                       |                                     |
                                         |                                     |
5.                                       |                                     |
                                         |                                     |
6.                                       |                                     |
                                         |                                     |
7. Design and Construct Test Equip-      |-------------                        |
   ment                                  |  (12m/m)                            |
8. Evaluate Leak Detection Candidates    |             ----                    |
                                         |             (2m/m)                  |
9. Develop Procedures                    |                 ------              |
                                         |                 (4m/m)              |
10.Prepare Final Report                  |                        ------       |
                                         |                        (4m/m)       |
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REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
218M04	HABITABLE VOLUME LEAK POINT LOCATION	6-27-85

SUMMARY SCHEDULE/COST FACTORS

STUDY SPAN:	OCT 85-JUL 88 CM = 34	
CATEGORY	FACTOR/MM(CM)*	COST $
LABOR		
- NASA Project Mgmt		
- Study Mgmt	34 mm	
- Study Tasks		
- Analyst, Eng'g	49 mm	
- Special Skills:		
SPECIAL FACILITIES		
- Vacuum Chamber Testing	1 cm	
- Mock-up Evaluation	1 cm	
_ Space Shuttle Prototype Testing	1 cm	
TRAVEL		
- Coordination w/NASA & Aerospace companies		5 K
- Mockup Evaluation		2 K
- Demonstration Testing		2 K
MATERIALS		
- Fabrication		50 K
TEST PROGRAM		
- Vacuum Chamber Evaluation Testing		20 K
- Mock-up Evaluation Testing		10 K
- Demonstration Testing		50 K
OTHER (List)		

* MM = Manmonths; CM = Calendar Months

REPORT FORMAT 13 MANAGEMENT PLAN OVERVIEW

NUMBER	TITLE	DATE
218M05	QA ON-ORBIT VERIFICATION REQUIREMENTS	6-27-85

ISSUE #	TITLE	NEED DATE
2180201	QA ON-ORBIT VERIFICATION REQUIREMENTS	JAN 89
2180202	QA VERIFICATION TOOLS AND EQUIPMENT	JAN 86

OBJECTIVES:

(01) Identify the requirements for performance of QA verification tasks on-orbit (frequency, types, etc.).

(02) Determine the tools and equipment required to perform the QA verification function.

(03) Differentiate between the QA verification tools and equipment that are integral to the Space Station systems and those that are portable (carry on).

(04) Determine the physical, functional and personnel interfaces of the integral and portable QA veerification tools and equipment with the Space Station systems, and the services and accommodations which the Space Station must provide to enable tool and equipment operations.

BACKGROUND:

Maintenance of system quality during the life of the Space Station requires that quality verification tasks be defined and the capability be provided for their performance. Characteristics to be verified may include such things as equipment operating parameters, structural integrity, contamination control effectiveness, or the effectiveness of operational and manufacturing processes. Verifications may be performed remotely by ground commands/sensing, but if the Station is required to function autonomously in later missions, as is indicated in present specifications, the verification capability must also be available on-orbit.

The capability may be integrated into individual Space Station systems to allow verification function to be performed automatically. It is also anticipated that some portable verification tools and equipment will be required, with specialized or multiple purpose capabilities. In order to establish an effective quality program, a thorough assessment of the total Space Station system must be completed. The verification requirements, the tools/equipment that must be provided, and the crew tasks involved must be established and considered during the Space Station design phase.

Space Station Program Operations Plan (POP) 488-40 contains two tasks that are directed toward providing a definition of Space Station on-orbit verification requirements, the crew related activities, and the necessary tools and equipment. The tasks, for which detailed activity plans were prepared in May, 1985, are entitled "Develop

On-orbit Quality Assurance Verification Methods/Techniques", and "Develop On-orbit Methods and Requirements for Non-Destructive Examination (NDE) Methods and Techniques, and Determine Minimum Equipment and Standards to be Used for NDE in Space".

INPUTS:

A. None

CRITICAL ASSUMPTIONS:

(01) Space Station POP 488-40, tasks "Develop On-orbit Quality Assurance Verification Methods/Techniques", and "Develop On-orbit Methods and Requirements for NDE Methods and Techniques and Determine Minimum Equipment and Standards to be Used for NDE in Space" will be funded and the work described by the tasks completed in time to support the Space Station master schedule.

(02) The work will be performed by the Level B Safety, Reliability, and Quality Assurance office of the Space Station Program, or by a support contractor at the Level B Nasa center.

SPECIAL REMARKS:

(01) Resolution of these issues will validate and permit completion of Requirements 21802-01(a), (c) and (j) and 21801-02(c).

(02) Design impact trade study data regarding the impact of dual occupancy for task verification will be defined in Management Plan 401M02 - Task Verification at Workstations.

(03) Minimizing crew workload is a primary consideration in the selection of hardware and procedures.

(04) Resolution of these issues must take into account that some critical IVA tasks will be performed by an EMU-suited crewmember (damage repair).

REFERENCES:

(01) None

REPORT FORMAT 13 MANAGEMENT PLAN OVERVIEW

NUMBER	TITLE	DATE
218M07	FLUID SYSTEM VERIFICATION	6-27-85

ISSUE #	TITLE	NEED DATE
2180203	FLUID SYSTEM VERIFICATION	SEP 86

OBJECTIVES:

(01) For each fluid system, determine the need for system verification.

(02) For systems requiring verification, determine the requirements for fluid system access, fluid sampling, and sample analysis.

(03) Determine the fluid system, inflight support equipment, and interface design requirements that will enable the verification task to be performed.

BACKGROUND:

The Space Station will be the first United States continuously manned, long term space vehicle. With an indeterminant life expectancy of up to twenty years, fluid system designs must take into account numerous areas that were not previously considered. In the past, except for potable water systems, fluid system design considered system access, sampling, and sample analysis as tasks that were performed during pre-launch processing and not repeated after launch. Water systems were accessed for the introductions of chemical purification agents rather than for sampling and sample analysis. Determination of the reasons for "funny tastes" or other observed characteristics was made by engineering analysis or by sampling and laboratory analysis after the spacecraft returned to earth.

Space Station fluid distribution and control systems will tend to be more complex than for previous spacecraft. The fluid containment period will probably be much longer creating a greater chance for induced contamination. Therefore a means for an orbit fluid system verification (accessing, sampling, and analysis) must be considered during the design stage.

INPUTS:

A. SPACE STATION FLUID SYSTEM DEFINITIONS: TYPES OF FLUIDS, FLUID STORAGE, DISTRIBUTION, AND CONTROL CONCEPTS.

B. FLUID CHARACTERISTICS: SUSCEPTIBILITY TO CONTAMINATION, SAMPLING AND ANALYSIS REQUIREMENTS FOR SYSTEM VERIFICATION AFTER LONG TERM STORAGE.

C. SPACE STATION SYSTEM VERIFICATION EQUIPMENT DESIGN CONSTRAINTS (WEIGHT, SIZE, POWER, ETC.).

CRITICAL ASSUMPTIONS:

(01) Fluid system verification will not create a crew hazard or impact the operation of the system being verified.

(02) Fluid systems will be designed as integral, maintainable parts of the Space Station and not as modules to be removed ano replaced during resupply activities.

(03) Built-in sampling and analysis equipment for determining the condition of fluid system contents will be used when feasible.

(04) The Space Station will be operated in the manned mode and will be autonomous, or nearly autonomous, after earlier missions.

(05) The crew will be trained and equipped to perform the fluid systems verification task, and will be able to correct observed deficiencies.

(06) Study task schedule asssumes an Initial System Review date of Jan. 86.

SPECIAL REMARKS:

(01) For purposes of this plan, accessing is considered to cover two specific tasks: a) Gaining physical access to elements of the system (through removal of protective panels, relocating equipment modules, etc.), b) Gaining access to the contents of a fluid system (through removal of sampling port caps or plugs, use of built in test probes, or etc.). Access by an EMU-suited crewman during damage assessment/repair must be taken into account.

(02) For the purpose of this study, fluid system verification is defined as determining that the contained fluid will satisfy the intended use. The study will not consider corrective action if the fluid is not within allowable specifications.

(03) The completion date for this activity was established considering the need for defining system design requirements prior to the development of the Phase C and D Request for Proposal. Other activity, such as the design or adaptation of existing designs for fluid sampling and analysis support equipment may be required beyond that date.

(04) Minimizing crew workload must be a primary factor in the selection of equipment and procedures.

REFERENCES:

(01) JSC-SN-C-0005, Contamination Control Requirements for the Space Shuttle Program, Mar 1982.

(02) JSC-SE-S-0073, Space Shuttle Program Specification - Space Shuttle Fluid Procurement and Use Control, Chg 20, Jan 1981

(03) MSFC-PROC-0404, Gases, Drying and Preservation, Cleanilness Level, and Inspection Methods, Oct 1964

NUMBER	TITLE	DATE
218M07	FLUID SYSTEM VERIFICATION	6-27-85

STUDY TASKS:

(01) Literature Review - Review the literature in two areas of interest: a) Determine the long term storage characteristics of the fluids and fluid systems equipment (e.g., susceptibility to internal and external contamination; chemical, physical, bacteriological, or other changes that may occur under stagnant and intermittently stagnant conditions; the compatibility of system materials and fluids; the effect of temperature and pressure variations internal and external to the system; and sampling and analysis types, frequencies, etc., used for similar ground based systems verification). b) Identify applicable existing, off-the-shelf, fluid analysis equipment designs. The review should consider equipment that can be build into a fluid system as well as equipment that can be used for analysis of fluid samples withdrawn from a system. This portion of the review may be done to obtain information related to fluid system verification in general, or in response to a need for verification of a specific fluid system. The review may therefore continue through much of the time required to complete the overall task.

(02) Test Facility Contacts - Contact governmental or quasi-governmental test facilities such as the NASA White Sands Test Facility or the Battelle institute for fluid and fluid systems information that is not available in published reports. The zero gravity fluids test programbeing done by the Crew Systems Division at JSC may also be a good information source.

(03) Testing - Perform laboratory testing as necessary to determine fluid and/or fluid system characteristics that are indeterminable from the literature review or from contact with accessible test organizations.

(04) Verification Specifications - Prepare verification requirements specification sheets for each fluid system design to be used on the Space Station. Each specification sheet should include at least the following information: a) Fluid-nomenclature; chemical or physical composition; normal state; limits on acceptable states; and special handling and safety precautions. b) Allowable impurities-nomenclature; chemical or physical composition; normal state; and allowable limits and effects of out-of-limit conditions. c) Verification requirements - frequency; sample physical requirements (volume, source location, number per verification, etc.); sample purity, life limits, or other handling requirements; allowable measurement accuracy for impurity determination, need for EMU-suited crewmember access, etc. It may also be determined that there is no requirement for system verification.

(05) Verification Method Trade Study - Perform a trade study of candidate verification methods and techniques having potential application for Space Station. Consider such factors as size, weight, and power requirements. safety of operation, accuracy and reliability, ease or simplicity and time requirements of method, multiple applicability, and future applications. Minimizing crew workload will be a primary trade criteria. Include consideration of built-in verification equipment, modular designs, and bench type approaches. The result of the study should be recommended concept for verification fo each fluid system (unless it is determined that verification is not required), with rationale to support the recommendation.

(06) System Design Requirements - Develop the design requirements for fluid systems necessary to implement recommended verification methods.

(07) Interface Design Requirements - Develop the design requirements for systems and equipment that interface with fluid verification equipment or that may affect the ability to perform the verification task (access obstruction, susceptibility to contamination, etc.).

(08) Equipment Design Specifications - Develop design specifications for sampling and analysis equipment recommended for fluid systems verification, or identify existing designs that are adequate or that can be adapted for use on-orbit.

(09) Procedure Requirements - Develop requirements for inflight procedures necessary for implementing the verification methods recommended for application to Space Station.

SPECIAL STUDY NEEDS:

TASK(S)	NEED
3	Laboratory or test facility

SPECIAL SKILLS:

TASK(S)	SKILL
3	Familiarity with laboratory test procedure

PERFORMING ORGANIZATION:

(01) Managing: NASA Level B, JSC Quality Assurance Organization

(02) Doing: NASA test facility.
Commercial or quasi-governmental test organization.
Prime contractor.

STUDY PRODUCTS:

•

(01) Recommended Space Station Fluid systems verification requirements.

(02) Recommended methods and techniques for performance of fluid system verifications considered necessary.

(03) Space Station system, interface, and support equipment design specifications to allow on-orbit fluid system verifications.

(04) In-flight crew procedures requirements specifications.

PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS:

SUBELEMENT NO. & TITLE	Undefined Rqmt #
21802 Condition Verification	-01.d, -01.c (partial)

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
218M07	FLUID SYSTEM VERIFICATION	6-27-85

	1984			1985								
CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S
FISCAL	FY 85											
MONTH	1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												
STUDY TASKS												
Assuming: June 86 for ISR										A		
										B		
1. Literature Review										----------	----------	----------

REPORT FORMAT 13 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
218M07	FLUID SYSTEM VERIFICATION	6-27-85

	1985			1986								
CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S
FISCAL	FY 86											
MONTH	1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												
STUDY TASKS												
Assuming: June 86 for ISR												
1. Literature Review	---	---	---	---	---	---	---	---	---			
					(2m/m)							
2. Test Facility Contacts	---	---	---									
		(1m/m)										
3. Testing	---	---	---	---	---							
			(2m/m)									
4. Verif. Specs.						---	---					
						(1m/m)						
						C						
5. Trade Study						---	---	---				
							(2m/m)					
6. System Design Requirements							---	---				
							(1m/m)					
7. Interface Design Requirements							---	---				
							(1m/m)					
8. Equipment Design Specifications									---	---	---	
										(2m/m)		
9. Procedure Requirements										---	---	
											(1m/m)	

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
218M07	FLUID SYSTEM VERIFICATION	6-27-85

SUMMARY SCHEDULE/COST FACTORS

STUDY SPAN: JUL 85-SEP 86 CM = 16

CATEGORY	FACTOR/MM(CM)*	COST $
LABOR		
- NASA Project Mgmt		
- Study Mgmt	4.0 mm	
- Study Tasks		
- Analyst, Eng'g	11.0 mm	
- Test, Eng'g	0.5 mm	
- Test, Technician	1.5 mm	
SPECIAL FACILITIES		
TRAVEL		
- Study coordination with NASA		4 K
- Coordination with test facilities		10 K
MATERIALS		
- Cost included in test program costs		
TEST PROGRAM		50 K
OTHER (List)		

* MM = Manmonths; CM = Calendar Months

REPORT FORMAT 13 MANAGEMENT PLAN OVERVIEW

NUMBER	TITLE	DATE
218M08	EQUIPMENT STATUS MARKING ON-ORBIT	6-24-85

ISSUE #	TITLE	NEED DATE
2180302	EQUIPMENT STATUS MARKING ON-ORBIT	SEP 86

OBJECTIVES:

(01) Assess the advantages and feasibility of developing a method of physically identifying equipment on orbit to include appropriate status information.

(02) Develop the operations requirements and crew procedures for implementing a method of equipment status marking (adjustment, calibration, discrepant condition, enclosure integrity, certification, etc.) while on orbit.

(03) Identify appropriate materials and methods to display the status of Space Station onboard equipment.

BACKGROUND:

Physically displaying the operational status of highly sophisticated or critical equipment is a standard procedure for most laboratory or test facility operations. The practice is used to supplement status record maintenance and serves several functions. The calibration or certification status is frequently shown to either advise the potential user that inaccurate results may be obtained if the equipment is used, or that the equipment is unsafe for use. Integrity markings are used to prevent undetected unauthorized adjustments of control, measurement, safety, or other equipment features. Markings may be used to indicate the time of last equipment maintenance, especially when use beyond the required maintenance interval may result in system damage. When systems or components are found to be discrepant through inspection or operational malfunctions, some means of physically marking the equipment to advise potential users of the discrepant condition is usually employed. Marking may be in the form of cautions against further use, advisories as to constraints to use, or special procedural steps required when the equipment is used. Regardless of the purpose of the markings, the need for them increases as the complexity of operations or the number of personnel working in an area increases.

The applicability to Space Station operations of the concept of marking the status of equipment on the actual article has yet to be established. The concept may not only be desirable but necessary for safe and efficient operations. Consideration of the number of crew personnel, the variety of operations to be performed, the relatively small volume and consequent density of equipment placement, and the short interval between periods of crew rotation may establish a requirement for equipment status marking. This issue resolution study will analyze these factors.

INPUTS:

A. EQUIPMENT IN SPACE STATION SYSTEMS TO WHICH THE CONCEPT OF STATUS INFORMATION MARKING MAY APPLY (E.G., EQUIPMENT THAT WILL BE ADJUSTED, CALIBRATED, MAINTAINED, OR RECTIFIED; EQUIPMENT THAT IS ENCLOSED FOR REASONS OF SECURITY; OR EQUIPMENT THAT SHOULD BE OPERATED OR ADJUSTED ONLY BY QUALIFIED PERSONNEL)

B. SPACE STATION PROGRAM NONMETALLIC MATERIALS APPLICATION CONSTRAINTS, INCLUDING IDENTIFICATION OF MATERIALS ACCEPTABLE FOR USE.

CRITICAL ASSUMPTIONS:

(01) Crew rotations will occur at 3-month intervals witn total crew rotation at one time.

(02) The flight crew will have the necessary knowledge, skill, information, tools and equipment, and opportunity to adjust, calibrate, recertify, maintain, or otherwise cause changes to the status of systems throughout the on-orbit life of the Space Station.

(03) Space Station operations will be autonomous, or nearly autonomous, after the early missions.

(04 It will not be necessary to implement a method of equipment status marking until active Space Station missions are initiated. The proposed schedule reflects this assumption.

(05) The method to be recommended may involve the requirement for general use of nonmetallic materials within habitable volumes. A large number of materials have been tested and approved for exposure to the spacecraft interior environment. It is assumed that this will permit selection of materials acceptable for use in identifying equipment status without need for further testing. No schedule time or cost factors were allocated for materials flammability or toxicity testing.

SPECIAL REMARKS:

(01) Minimizing crew workload is the primary criteria in selection of equipment status marking techniques.

REFERENCES:

(01) SSP (TBD), Product Assurance Requirements for the Space Station Program, (RFT Accession No. J8400001), July 18, 1984

(02) JSC 8070B, JSC Metrology Requirements Manual, Appendix B, Metrology Labels, Nov 26, 1975

(03) NHB 8060.1B, Flammability, Odor, and Offgassing Requirements and Test Procedures for Materials in Environments That Support Combustion, Sept. 1, 1981

(04) JSCM 5312, JSC SR&QA Procedures Manual, Oct. 1984

NUMBER	TITLE	DATE
218M08	EQUIPMENT STATUS MARKING ON-ORBIT	6-24-85

STUDY TASKS:

(01) Survey Status Marking Practices - Review current literature and survey practices at technical laboratories and similar facilities to determine the necessity for equipment status marking and the alternative approaches used.

(02) List Candidate Equipment - Determine candidate equipment items for which status should be displayed, the type of status that should be reflected, and the justification for displaying the status of each item. Items to be considered should include equipment requiring periodic calibration or recertification, discrepant equipment, equipment requiring critical adjustments, controlled access enclosures, mechanical or electrical connections, and critical equipment that has been verified and that is ready for installation.

(03) Validate Equipment Listing - Coordinate the candidate equipment listing with ground and flight operations personnel to obtain concurrence on the validity of the listing.

(04) Determine Status Marking Methods and Materials Assessment - Determine the methods and materials to be used to provide the capability to display equipment status. Materials selection criteria should include considerations of safety, durability, contamination potential, ease of use, and crew time required.

(05) Develop Status Marking Specification - Prepare a summary specification of equipment items for which status should be displayed, the information to be provided, the type of display device, materials to be used, the type of marking, and the justification for each specified requirement.

(06) Develop Flight Procedure Requirement - Develop the requirements for flight procedures to be used for implementing a system of displaying equipment status on individual equipment items.

SPECIAL STUDY NEEDS:

TASK(S)	NEED
	None identified

SPECIAL SKILLS:

TASK(S)	SKILL
1,2,3,4,5,6	Quality Assurance Specialist
3	Astronauts
3	Ground Operations Specialist

PERFORMING ORGANIZATION:

(01) Managing: NASA Level B, JSC Quality Assurance Organization

(02) Doing: Aerospace Prime Contractor (prime)
Research contractor (sub)
NASA research center

STUDY PRODUCTS:

(01) Specification of requirements for marking status of equipment on orbit.

(02) Requirements for flight procedures for implementing a system of on-orbit equipment status marking.

(03) Recommended materials and methods for accomplishing equipment status marking on-orbit.

PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS:

SUBELEMENT NO. & TITLE	Undefined Rqmt #
21803 Control	-01a

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
218M08	EQUIPMENT STATUS MARKING ON-ORBIT	6-24-85

```
                                    1987         |     1988                                    |
                            CALENDAR|O--N--D--|J--F--M--A--M--J--J--A--S--|
                              FISCAL|FY 88                                                     |
                               MONTH|1  2  3   4  5  6  7  8  9  10 11 12 |
                             PHASE B|                                                          |
                                   C|                                                          |
STUDY  TASKS                        |                                                          |
                                    |A                                                         |
1. Survey Status Marking Practices  |---------                                                 |
                                    |  (3mm)                                                   |
                                    |                                                          |
2. List Candidate Equipment         |         ------                                           |
                                    |         (2mm)                                            |
                                    |                                                          |
3. Validate Equipment Listing       |               ------                                     |
                                    |               (2mm)                                      |
                                    |                    B                                     |
4. Determine Status Marking Methods |                    ---                                   |
                                    |                   (1mm)                                  |
                                    |                                                          |
5. Develop Status Marking Specifi-  |                       ---                                |
   cation                           |                      (1mm)                               |
                                    |                                                          |
6. Develop Flight Procedures Require-|                            ---                         |
   ment                             |                           (1mm)                          |
                                    |Total = 10mm                                              |
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REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
218M08	EQUIPMENT STATUS MARKING ON-ORBIT	6-24-85

SUMMARY SCHEDULE/COST FACTORS

STUDY SPAN: Oct 87-Sep 88 CM = 12

CATEGORY	FACTOR/MM(CM)*	COST $
LABOR		
- NASA Project Mgmt		
- Study Mgmt	3.0 mm	
- Study Tasks		
- Analyst, Eng'g	10.0 mm	
- Special Skills:		
SPECIAL FACILITIES		
TRAVEL		
- Coordination with NASA		$5K
- Laboratory/facility survey		$5K
MATERIALS		
TEST PROGRAM		
OTHER (List)		

* MM = Manmonths; CM = Calendar Months

REPORT FORMAT 13 MANAGEMENT PLAN OVERVIEW

NUMBER	TITLE	DATE
218M09	ON-ORBIT QUALITY ASSURANCE RECORDS	07-17-85

ISSUE #	TITLE	NEED DATE
2180602	ON-ORBIT QUALITY ASSURANCE RECORDS	SEP 87

OBJECTIVES:

(01) Develop an integrated quality assurance record system to be used by in-flight personnel during the Space Station Program.

(02) Develop data elements and report formats for individual reports required to implement an on-orbit quality assurance record system.

(03) Develop an estimate of the quality assurance record system data processing requirements.

BACKGROUND:

The preparation and maintenance of quality assurance records during previous NASA manned spaceflight missions was either accomplished by ground personnel or not accomplished at all. In general, if records were prepared, the source data were obtained from transcripts of recorded crew in-flight voice comments, recorded space-to-ground communications, or postmission debriefing notes; or from reports prepared for reasons other than quality assurance purposes.

This approach was satisfactory for previous programs, primarily because there was a break in the action which allowed rebaselinig the details of the hardware/software systems to be used for the next mission. A major factor in the Skylab Program, during which a minor amount of system reconfiguration and repair was accomplished in flight, was that the system was rudimentary in comparison to the extent and complexity of the proposed Space Station system.

For the Space Station Program, a well conceived and properly implemented plan for in-flight quality assurance recording and reporting should provide a valuable contribution to effective operation of the system during the extended operational deployment in space.

INPUTS:

A. Detailed definitions of other reporting and recording systems to be implemented during the Space Station operations phase.

B. Management Communication and Data Storage (MCDS) System definition.

CRITICAL ASSUMPTIONS:

(01) The Space Station will be operated in the manned mode.

(02) Operations crews will be responsible for all hardware and software systems operations, inspection, evaluation, modification, repair or refurbishment, or assessment (i.e., there will be no missions designated as refurbishment, reconfiguration, maintenance, or assessment missions).

(03) The operation of the Space Station will be autonomous or nearly autonomous after early missions.

(04) The flight crew will have the necessary knowledge, skill, information, tools and equipment, and opportunity to perform quality assurance functions during active mission phases.

(05) The schedule established for completion of the activities defined in this plan assumed no hardware impact from the requirement and minimal software impact. The schedule will provide an estimate of data processing requirements by PDR.

(06) Assumes Jan 88 for PDR.

<u>SPECIAL REMARKS</u>:

(01) Quality assurance records may be made directly as such, or be developed wholly, or in part, by selection of data fields from other reports or from permanent memory banks in the MCDS.

(02) References 01-06 must be considered during the execution of this study.

<u>REFERENCES</u>:

(01) SSP (TBD), Product Assurance Requirements for the Space Station Program, (RFP Accession No. J8400001), 18 Jul 1984

(02) MIL-Q-9858A, Quality Program Requirements, 7 Aug 1981

(03) MIL-Q-21549B, Quality Program Requirements for Fleet Ballistic Missile Weapon System Contractors, 10 Jun 1963.

(04) MIL-I-45208A, Inspection System Requirements, 16 Dec 1963

(05) JSCM 8070B, JSC Metrology Requirements Manual, Nov 1975

(06) JSCM 5312, JSC SR&QA Procedures Manual, Oct 1984

REPORT FORMAT 14 STUDY PLAN

NUMBER	TITLE	DATE
218M09	ON-ORBIT QUALITY ASSURANCE RECORDS	07-17-85

STUDY TASKS:

(01) Review Literature - Perform a review of selected literature to identify the types of quality assurance records required for ground based operational systems similar in function to Space Station and the reasons that the records are prepared and maintained.

(02) Perform Trade Studies - Perform a series of trade studies to evaluate the various types of reports which should be required during the Space Station operational phase. Specific records which should be evaluated include discrepancy and failure reports*, inventory records, equipment recertification*, traceability, discrepant parts control, time/cycle recording, quality audit reports, equipment operational status reports, and configuration modification verification reports*. The studies should consider: a) The benefits to be derived from the report/record, b) The crew time required to prepare the report or to provide the data for report preparation by ground personnel, c) The possible availability of adequate information from other reporting systems, and d) Other factors which could determine the desirability of preparing and maintaining each report/record.

The end result of the studies should be an integrated set of quality assurance reports required during Space Station flight operations and the justification rationale for each report/record.

*These reports are the subject of separate issue resolution Management Plans (218M01, On-Orbit Configuration Mods Verification, 218M02, On-Orbit Problem Reporting System, and 218M10, On-Orbit System Certification Requirements).

(03) Develop Data Elements - Develop data elements and recording formats for records that are recommended.

(04) Determine Data Collection Method - Determine the most effective and efficient method of collecting and reporting the data elements for each report type recommended. The method should recognize the possibility of obtaining data elements through ground personnel inputs or through the Space Station system data processing capabilities. The feasibility of advanced hardware data reporting techniques such as the use of bar codes should be examined.

(05) Estimate Data Processing Requirements - Develop an estimate of the data collection, storage, and retrieval processing required by the Space Station data processing system to maintain the recommended integrated quality assurance record system.

SPECIAL STUDY NEEDS:

TASK(S)	NEED
	None

SPECIAL SKILLS:

TASK(S)	SKILL
	None

PERFORMING ORGANIZATION:

(01) Managing: NASA Level B, JSC SR and QA Division

(02) Doing: Aerospace Contractor (Prime)
Consulting Engineering Organization (Sub)

STUDY PRODUCTS:

(01) Recommended list of individual on-orbit quality assurance reports, which together comprise an integrated quality assurance record system that is to be maintained during the Space Station Program operational phase. Justification for each record and for the system are to be included.

(02) Data elements, record format, and recommended data collection method for each on-orbit quality assurance report.

(03) Estimate of total data processing capability required for the Space Station on-orbit quality assurance integrated record system.

PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS:

SUBELEMENT NO. & TITLE	Undefined Rqmt #
21806 REPORTING AND RECORDING	-02

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
218M09	ON-ORBIT QUALITY ASSURANCE RECORDS	07-17-85

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                                        1986        |  1987                                |
                               CALENDAR|O--N--D--|J--F--M--A--M--J--J--A--S--|
                                 FISCAL|FY 87                                        |
                                  MONTH|1  2  3   4  5  6  7  8  9  10 11 12 |
                                PHASE B|                                             |
                                      C|                                             |
STUDY  TASKS                           |                                             |
Assuming:  Jan 88 PDR                  |A                                            |
1. Review Literature                   |---------                                    |
                                       |(2 mm)                                       |
2. Perform Trade Studies               |          ---------                          |
                                       |          (4 mm)                             |
3. Develop Data Elements               |                B                            |
                                       |                ------------------           |
                                       |                     (6 mm)                  |
4. Determine Data Collection Method    |                           -------           |
                                       |                           (2 mm)            |
5. Estimate Data Processing Require-   |                              ---            |
   ments                               |                             (1 mm)          |
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REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
218M09	ON-ORBIT QUALITY ASSURANCE RECORDS	07-17-85

SUMMARY SCHEDULE/COST FACTORS

STUDY SPAN: OCT 86-SEP 87 CM = 12

CATEGORY	FACTOR/MM(CM)*	COST $
LABOR		
- NASA Project Mgmt		
- Study Mgmt	4 mm	
- Study Tasks		
- Analyst, Eng'g	15 mm	
- Special Skills:		

SPECIAL FACILITIES

TRAVEL

MATERIALS

TEST PROGRAM

OTHER (List)

* MM = Manmonths; CM = Calendar Months

REPORT FORMAT 13 MANAGEMENT PLAN OVERVIEW

NUMBER	TITLE	DATE
218M10	ON-ORBIT SYSTEM CERTIFICATION REQUIREMENTS	6-27-85

ISSUE #	TITLE	NEED DATE
2180401	ON-ORBIT SYSTEM CERTIFICATION REQUIREMENTS	SEP 86

OBJECTIVES:

(01) Determine equipment requiring periodic recertification on-orbit for continued safe and reliable operation.

(02) Identify the specific requirements for recertification of each equipment candidate identified.

(03) Determine system and support equipment design requirements necessary to implement an on-orbit recertification program, including a system for maintenance and display of certification status.

(04) Determine the crew involvement in each recertification procedure.

BACKGROUND:

It has long been a practice in operation of Earth-based facilities to identify the elements of the facility that could become unreliable or unsafe. This may result from age, hours of operation, extended out-of-service periods, unexpected operational environments, or other causes. When such systems are identified, a program of recertification for continued use is usually employed. In the operation of some equipment, such as boiler plants or oxygen systems, recertification is required by law. Significant components of the system are subjected to some form of periodic inspection of test. The results are used, directly or indirectly, to determine the readiness for futher operations. The refurbishment or maintenance actions necessary to establish operational readiness are also determined.

System recertification during a mission has not been necessary on previous spacecraft, although the treatment of the Space Transportation System Orbiter during turnaround amounts to essentially the same thing.

The extended life on-orbit planned for the Space Station, however, indicates that some discipline should be established to determine periodically whether individual systems have become unsafe or unreliable. A formal recertification program patterned on the programs which have been established at the NASA Centers is recommended. While the NASA Center programs are oriented toward hazardous operations, it is suggested that the Space Station on-orbit programs cover any subsystems where periodic recertification appears desirable to assure safe or reliable operation.

INPUTS:

A. DEFINITION OF EACH SPACE STATION SYSTEM.
B. OPERATION, NON-OPERATION, AND STORAGE PROFILE FOR SYSTEM ELEMENTS.
C. SYSTEM OPERATIONAL OR STORAGE ENVIRONMENT.
D. BUILT-IN TEST/AUTOMATIC VERIFICATION CAPABILITIES PLANNED FOR EACH SYSTEM.
E. WEIGHT/VOLUME CONSTRAINTS ON PROVISIONS FOR RECERTIFICATION.

CRITICAL ASSUMPTIONS:

(01) No missions will be designated for repair or refurbishment only.

(02) The flight crew will have the necessary knowledge, skill, information, tools and equipment, and responsibility for preserving the operational capabilities of the Space Station system.

(03) The Space Station will operate autonomously or nearly autonomously after the early missions.

(04) Crew rotation will occur without periods of unmanned operation and will consist of the change-out of the entire crew at one point in time.

(05) Initial system certification will be performed before launch.

(06) Recertification activities will not create a hazard to the crew or disrupt normal spacecraft operations.

(07) The period between recertification of safety related systems will exceed the normal logistics cycle.

(08) EVA can be considered in determining the feasibility of system recertification.

(09) The schedule for resolution of this issue was based on the need for systems design requirement definition before start of preliminary design, and assumes an ISR date of June 86 and a PDR date of January 88.

SPECIAL REMARKS:

(01) The subject of system recertification on-orbit is tentatively scheduled as a topic on the agenda for a Pressure Systems Seminar scheduled for the month of September or October, 1985, at Langley Research Center.

(02) It is realized that systems definition will be in the development stages at the recommended task start date. The use of best estimates by NASA systems engineers of system characteristics may be necessary.

(03) For the purposes of this task, recertification is defined as the determination, by a person with the proper training, that adequate verification inspection and test procedures have been performed to assure that a system has has not degraded to an unsafe or unreliable condition since initial certification or the last recertification, or to identify and verify correction of discrepancies which must be resolved before continued system operation. The corrective action to be taken for discrepancies will not be considered in any detail.

(04) References 01 - 06 must be considered during the execution of this study.

(05) Minimization of flight crew's workload is a primary factor in the selection of the certification system.

REFERENCES:

(01) JSCM 1710, Certification and Recertification of Ground Based Pressure Vessels and Pressurized Systems.

(02) NHB 1700.6, Guide for Inservice Inspection of Ground Based Pressure Vessels and Systems.

(03) NHB 1710.1, Volume 3, NASA Safety Manual, System Safety.

(04) NSS/HP-1740.1, NASA Aerospace Pressure Vessel Safety Standards.

(05) NSS/HP-1740.4, NASA Medium Weight Pressure Vessel Safety Standards.

(06) T.O. 00-25-223, Technical Operations Manual, Integrated Pressure Systems and Components.

NUMBER	TITLE	DATE
218M10	ON-ORBIT SYSTEM CERTIFICATION REQUIREMENTS	6-27-85

STUDY TASKS:

(01) Identify Candidate Systems - Assess each Space Station system to identify those that are candidates for a recertification program. The assessment should consist of evaluating the system function, electrical or electronic assemblies, software interface, mechanisms, materials, operating or storage environment, or other characteristics to determine the potential for functional degradation caused by age, length of operation, operational stress, static loads, or other factors. Typical candidate systems are: a) fire detection and suppression, b) oxygen and nitrogen storage and distribution, c) coolant fluid storage and distribution, d) fuel and oxidizer storage and distribution, e) hatch seals/sealing surfaces, f) space suits and manned maneuvering units, g) emergency breathing apparatus, h) waste collection, treatment and storage, i) potable water storage, treatment, and distribution, j) environmentally controlled work station equipment.

(02) Determine Recertification Requirements - For each system candidate for recertification, determine by analysis and by coordination with appropriate technical disciplines the verifications requirements and the allowable period between recertifications. For each verification requirement, establish the most appropriate test or inspection technique. Determine if the test or inspection will be performed using built-in test or instrumentation systems or manually by the crew.

(03) Develop System Design Requirements - Develop the system design requirements which allow access and inspection and test verifications necessary to recertify each candidate system.

(04) Develop Support Equipment Requirements - Develop the design requirements for the support equipment necessary to implement a recertification program for each candidate system.

(05) Determine Crew Procedures Requirements - Determine the requirements for crew procedures which must be prepared to enable recertification of each candidate system.

(06) Determine Integration Requirements - Determine the appropriate relationship between the recertification program and other activities such as maintenance, calibration, and logistics.

(07) Establish Documentation Requirements - Establish the documentation necessary to control the recertification program (i.e., maintain/display status).

SPECIAL STUDY NEEDS:

TASK(S)	NEED

	None

SPECIAL SKILLS:

TASK(S)	SKILL
	None

PERFORMING ORGANIZATION:

(01) Managing: NASA Level B, JSC Quality Assurance Organization.

(02) Doing: Aerospace Contractor (Prime)
Test Laboratory (Sub)

STUDY PRODUCTS:

(01) Identification of Space Station systems which should be periodically recertified for continued use, and the verification inspection and test activities necessary for system recertification.

(02) System design requirements necessary for a successful recertification program.

(03) Support equipment design requirements.

(04) Requirements for procedures used in equipment recertification.

(05) Requirements for the documentation system used to control the recertification program.

(06) Definition of the relationship between system recertification and other related activities such as maintenance or calibration.

PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS:

SUBELEMENT NO. & TITLE		Undefined Rqmt #
21804	Equipment Calibration/Certification	-03
21802	Condition Verification	-01c and (j) partial.

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
218M10	ON-ORBIT SYSTEM CERTIFICATION REQUIREMENTS	6-27-85

```
                                           1985        :     1986                                  :
                                CALENDAR:O--N--D--:J--F--M--A--M--J--J--A--S--:
---------------------------------------------------------------------------------------------------
                                  FISCAL:FY 86                                                       :
                                   MONTH:1   2   3    4   5   6   7   8   9   10  11  12  :
---------------------------------------------------------------------------------------------------
                                 PHASE B:                                                            :
                                       C:                                                            :
STUDY  TASKS                             :                                                           :
---------------------------------------------------------------------------------------------------
Assuming:  Jun 86 for ISR                :A.                                                         :
           Jan 88 for PDR                :B.                                                         :
                                         :C.                                                         :
1. Identify Candidate Systems            :---------------------------                                :
                                         :          (3m//m)                                          :
                                         :  D                                                        :
2. Determine Recertification Require-    :  E------------------------                                :
   ments                                 :            (5m/m)                                         :
3. Develop System Design Requirements    :            ------------------                             :
                                         :                  (3m/m)                                   :
4. Develop Support Equipment Require-    :                        --------------------------:
   ments                                 :                            (2m/m)                         :
5. Determine Crew Procedure Require-     :                              --------------------:
   ments                                 :                                  (2m/m)                   :
6. Determine Integration Requirements    :                                  ----------------:
                                         :                                      (1m/m)               :
7. Establish Documentation Require-      :                                  ----------------:
   ments                                 :                                      (1m/m)               :
```

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
218M10	ON-ORBIT SYSTEM CERTIFICATION REQUIREMENTS	6-27-85

SUMMARY SCHEDULE/COST FACTORS

STUDY SPAN: OCT 85-SEP 86 CM = 12

CATEGORY	FACTOR/MM(CM)*	COST $
LABOR		
- NASA Project Mgmt		
- Study Mgmt	4 mm	
- Study Tasks		
- Analyst, Eng'g	17 mm	
- Special Skills:		

SPECIAL FACILITIES

TRAVEL		
- Coordination with NASA on Study		5 K
- Coordination with designers for systems data		20 K

MATERIALS

TEST PROGRAM

OTHER (List)

* MM = Manmonths; CM = Calendar Months

REPORT FORMAT 13 MANAGEMENT PLAN OVERVIEW

NUMBER	TITLE	DATE
220M01	EQUIPMENT NOISE, VIBRATION & MOUNTING STANDARDS	07-19-85

ISSUE #	TITLE	NEED DATE
2200101	EQUIPMENT VIBRATION/MOUNTING STANDARDS	APR 87
2050103	ZERO-G EQUIPMENT NOISE STANDARDS	APR 87

OBJECTIVES:

(01) To establish standards for equipment mounting and vibration output under zero-g conditions so that vibration transmitted to, and resulting noise radiated by the supporting structure is within design noise limits.

(02) To establish standards for equipment noise radiated under zero-g conditions so that receiver space noise is within design limits.

BACKGROUND:

Under earth's one-g conditions, it is well established, both theoretically and experimentally, how spring-mass systems (machine, isolation mounts, support structure) behave. For a given unbalance or vibration level in the machine, mounts can be designed to control the power flow into the supporting structure and thus control the energy radiated as sound into the surroundings. The allowed noise levels in the workplace dictate the allowed amplitudes and spectra of the sound emitted by the machines (equipment) whether it is emitted directly from the machine or indirectly from supporting structure via energy transfer through the mounts. Under the zero-g Space Station conditions the one-g standards and allowables may not be valid.

First of all, it is almost certain that, due to the long-term exposure, the noise limits in the Space Station will be more stringent than those on earth (Ref. 01). Also, these limits will be affected by the closely coupled nature of work and rest areas and other factors such as isolation and hypokinesia (Ref. 02). This noise limit factor alone could dictate changes in vibration, mounting and noise emission standards.

These new standards, if determined under one-g conditions, may or may not apply to the zero-g situation because the noise and vibration generation characteristics will be different in space, i.e. equipment mounts will not be supporting any weight or an out of balance fan may not transfer the same energy to the machine casing, etc.

The present issue resolution management plan provides a technical approach for developing standards for equipment vibration levels, mounting and noise emission under zero-g conditions so that working and resting design noise and vibration limits are not exceeded.

INPUTS:

A. LONG-TERM NOISE EXPOSURE LIMITS UNDER ZERO-G CONDITIONS (Management Plan 205M03)
B. LOW FREQUENCY NOISE PREDICTIONS (Management Plan 205M01)
C. Designers best guess concerning: 1 Work and living space configuration, 2. Method and material of construction, 3. Interior materials requirements (Management Plan 104M01), and 4. Equipment type, location and run duration time.
D. Predicated or measured equipment noise and vibration output
E. Weight limitations on noise and vibration control material

CRITICAL ASSUMPTIONS:

(01) That Inputs A through D are available.

SPECIAL REMARKS:

(01) The only way that specifications for vibration and noise emission can rigorously be determined and evaluated is to have the following: 1. Continuous and intermittent noise level criteria, 2. A complete description of the Space Station shape, construction details, interior configuration, type and extent of interior finishing materials, 3. Number, type and location of all equipment, 4. Measured or estimated noise and vibration spectral output of each machine and also how it is mounted and to what it would be mounted.

(02) With this information in hand, one would then proceed to estimate the interior noise levels by considering the energy contribution from each source, the absorption by articles in the chamber, transmission loss through walls and energy dissipated by the structure itself. If the resulting estimated noise exceeded the specified limits, solutions could be determined for the component source(s) contributing to the excess and changes recommended and incorporated into the design if necessary. In the ideal case, a full-scale mockup would be available to verify the predicted levels and on which to verify design changes.

(03) Without having the above factors to work with well before design input deadlines, the specifications will, of necessity, default to either). simply obtaining the quietest, most vibration-free equipment possible or 2) trying to adapt to the zero-g case, some military specifications, such as MIL-STD 167, or 3) making assumptions, guided by some estimates by design personnel, about probable equipment and location, etc. and proceeding with an analytical estimate.

(04) These alternatives may or may not prove to be satisfactory and carry with them an element of risk that may be faced, further down the line, with the task of trying to apply "fixes" to a noise problem rather than being able to design the solution into the Space Station. Since these specifications are required before design details will be available alternative 3 above is the recommended course of action.

REFERENCES:

(01) "The Physiological Basis for Spacecraft Environmental Limits" by J. M. Waligora, NASA Reference Publication 1045.

(02) "Standards for Noise Levels in Cabins of Spacecraft During Long Duration Flights", by Y. M. Yuganov, V. V. Krjlov, and K. S. Kuznetsov. XVI th. International Astronautical Congress, Athens, Greece, 1965.

REPORT FORMAT 14 STUDY PLAN

NUMBER	TITLE	DATE
220M01	EQUIPMENT NOISE, VIBRATION & MOUNTING STANDARDS	07-19-85

STUDY TASKS:

(01) Literature Review - Review literature to establish current noise, vibration and mounting standards, noise duration limits and subjective responses to long-term noise under 1-g conditions.

(02) Define Interim Standards - Assemble panel of "experts" to try to formulate some interim standards which would guide Space Station design until such time as more rigorously derived standards can be determined.

(03) Obtain Station Physical Parameters - Gather data to obtain "best guess" projections from Space Station design group of all parameters required to estimate the interior noise levels.

(04) Define Noise Environment - Analytically estimate the total noise in the interior of the "preliminary-design" Space Station. Separate the estimated contributions to the total noise from each source and also the contribution from structure-borne noise. Vibration estimates will probably be based on a more stringent version of MIL-STD 167 in order to include a safety margin.

(05) Conduct Simulated Zero-g Test - Simulate the external zero pressure effect on reverberant noise ;build-up inside the Space Station by placing a model with an interior noise source inside a vacuum chamber. Measure the sound level and distribution inside with and without the vacuum.

(06) Verify Analytical Predictions - Use the results of Task 5 to verify the analytical prediction of this effect for the Space Station interior noise (Task 4).

(07) Formulate Standards - Formulate equipment noise, vibration and mounting standards.

SPECIAL STUDY NEEDS:

TASK(S)	NEED
5	Shop facilities
5	Laboratory support
4	Access to computer
5	Large vacuum chamber

SPECIAL SKILLS:

TASK(S)	SKILL
4	Specialist in finite element theory and application

PERFORMING ORGANIZATION:

(01) Managing: NASA-Langley

(02) Doing: Aerospace Firms (Prime)
Vibro-Acoustics Labs (Sub)

STUDY PRODUCTS:

Preliminary estimates of Space Station component and total interior noise.

Detailed specifications for equipment noise emission, vibration levels, and equipment mounting.

PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS:

SUBELEMENT NO. & TITLE	Undefined Rqmt #
22001 VIBRATION CONTROL	-01, -02
20501 NOISE CONTROL	-01, -02
22002 VIBRATION LIMITS	-01

REPORT FORMAT 15   SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
220M01	EQUIPMENT NOISE, VIBRATION & MOUNTING STANDARDS	07-19-85

```
                                          1985       |   1986                             |
                                  CALENDAR|O--N--D--|J--F--M--A--M--J--J--A--S--|
                                    FISCAL|FY 86                                        |
                                     MONTH|1  2  3   4  5  6  7  8  9  10 11 12 |
                                   PHASE B|                                             |
                                         C|                                             |
STUDY  TASKS                              |                                             |
                                          |A                                            |
                                          |B                                            |
1. Literature Review                      |------                                       |
                                          |(2 mm)                                       |
2. Define Interim Standards               |   -------                                   |
                                          |   (2 mm)                                    |
                                          |C                                            |
                                          |D                                            |
                                          |E                                            |
3. Obtain Station Physical Parameters     |----------                                   |
                                          | (3 mm)                                      |
4. Define Noise Environment               |      ----------------                       |
                                          |          (5 mm)                             |
5. Conduct Simulated Zero-g Test          |              -----------------------|
                                          |                  (7 mm)                     |
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REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
220M01 .	EQUIPMENT NOISE, VIBRATION & MOUNTING STANDARDS	07-19-85

	1986			1987								
CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S
FISCAL	FY 87											
MONTH	1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												
STUDY TASKS												
6. Verify Analytical Predictions	---	---	---									
	(3 mm)											
7. Formulate Standards				---	---	---						
				(3 mm)								

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
220M01	EQUIPMENT NOISE, VIBRATION & MOUNTING STANDARDS	07-19-85

SUMMARY SCHEDULE/COST FACTORS

STUDY SPAN: OCT 85-DEC 86 CM = 15

CATEGORY	FACTOR/MM(CM)*	COST $
LABOR		
- NASA Project Mgmt		
- Study Mgmt	4 mm	
- Study Tasks		
- Analyst, Eng'g	23 mm	
- Special Skills:	2 mm	
SPECIAL FACILITIES		
- Vacuum Chamber	2 cm	
- Data Reduction Lab	1 cm	
TRAVEL		
- Coordination w/NASA		8 K
MATERIALS		
- Model Fabrication		15 K
TEST PROGRAM		
- Test Preparation, Test, Data Reduction		30 K
OTHER (List)		

* MM = Manmonths; CM = Calendar Months

REPORT FORMAT 13 MANAGEMENT PLAN OVERVIEW

NUMBER	TITLE	DATE
301M01	ON-ORBIT TRAINING	05-20-85

ISSUE #	TITLE	NEED DATE
3010103	ON-ORBIT TRAINING COST AND BENEFITS	AUG 89
3010403	ON-ORBIT REFRESHER TRAINING	AUG 89
3010301	NON-CRITICAL TASK TRAINING ON-ORBIT	AUG 89
3060109	ON-ORBIT TRAINING TIME	AUG 89

OBJECTIVES:

(01) To define the type and amount of refresher training which could or should be provided on-orbit.

(02) To determine the value of training non-critical tasks on-orbit.

(03) And to compare the cost and the benefit of training a selected set of tasks on the ground (preflight) and on-orbit (OJT).

BACKGROUND:

It is NASA's expressed desire to reduce Space Station astronaut preflight training as compared with the past and current astronaut training programs by providing on-orbit and on-the-job (OJT) training. "Extensive preflight training capability shall be limited to critical system functions with emphasis on part-task training. Infrequent and low criticality task training capability shall be conducted on a minimum basis on the ground, supplemented by on-orbit refresher lessons, and OJT on-board capabilities,"(1). There are certain benefits to be derived from providing on-orbit training. For example:

- o the maintenance of performance criterion for critical tasks which are rarely performed,
- o the practice of emergency procedures,
- o the ability to develop cross-task skills which would allow for duty swapping,
- o the development of new skills as an off-duty activity and to relieve boredom,
- o and the reduction of preflight training time, and, therefore, a potential reduction in training cost.

While there is a potential for reducing training costs by reducing preflight training time, the ability to actually realize such savings is an open question. Some training activities can not be eliminated. For instance, on-orbit training would either have to be completedly self-managed or would require the supervision of training personnel, on-orbit or from the ground. In either case, performance evaluation would have to be done on-orbit.

On-orbit refresher training could be valuable for critical tasks which are seldom performed, such as emergency procedures. However, thorough preflight training could alleviate the need to do so if it could be demonstrated that performance of such tasks did not degrade substantially during a 90-day mission.

The cost of on-orbit duty time may be so prohibitively expensive (2) that on-orbit training can be considered only in the light of a spare time activity with the reward being the opportunity to swap duties during working hours. The use of on-orbit training as a "stimulating" activity could be especially productive if the training devices that are developed could be used as effectively on-orbit as on the ground.

These and other considerations should be resolved before a particular course of action is accepted. The management plan which is presented here will provide an approach for defining training costs and benefits and for structuring on-orbit training so that the greatest benefit can be provided for the least cost.

INPUTS:

A. Conceptual task analysis following PDR for a selected set of tasks, critical and non-critical.

B. Task performance criteria, minimum and desired competence, as a function of level of workload (3).

C. Crew activity scheduling:
Shift options, issue 3060102; recreation and leisure time requirements, issue 3060106; factors for work scheduling, issue 3060301.

CRITICAL ASSUMPTIONS:

(01) Only NASA can designate a task as critical or non-critical.

(02) A conceptual task analysis for a selected set of both critical and non-critical tasks will be performed soon after PDR.

(03) PDR will take place in March 1988.

SPECIAL REMARKS:

(01) The present study is not intended to cover every task which will be performed on Space Station. Rather it is intended to address a selected set of tasks upon which to base the cost and benefit analysis.

(02) The required task analysis assumes that decisions regarding the division of labor between humans and automated devices have been made.

(03) There will be a relationship between this management plan and issues: 3060102, Shift Options; 3060106, Recreation and Leisure Time Requirements; 3060301, Factors for Work Scheduling.

(04) The workload and performance criterion research being done under the supervision of Sandra Hart, NASA Ames Research Center, will facilitate the work to be done under this management plan.

(05) The development of an automated decision aid for the evaluation of the remaining tasks should be considered either within this program or as an extension of it.

(06) An outcome of the present work would include the identification of technologically sophisticated training devices and aids appropriate for future development.

REFERENCES:

(01) NASA Solicitation #9-BF-10-4-01P, "Space Station Definition & Preliminary Design, Request for Proposal," P. 3-C-11.

(02) THURIS: Generalization on Human Roles in Space. Vols I, II, III. McDonnell Douglas Astronautics Co., Huntington Beach, CA, MDC H1295, 1984.

(03) Hart, S. Telephone conversation, May 1985. NASA Ames Research Center, (415) 694-6072).

REPORT FORMAT 14 STUDY PLAN

NUMBER	TITLE	DATE
301M01	ON-ORBIT TRAINING	05-20-85

STUDY TASKS:

(01) A representative sample of critical and noncritical tasks will be selected by NASA to be evaluated for the cost, benefit, and risk involved in training each task: preflight, on-orbit refresher, partial on-orbit OJT, and on-orbit cross-task.

(02) Perform a literature review, including vendor documentation of training devices and programs which relate specifically to the tasks chosen for evaluation.

(03) Interview vendors and training developers to obtain information about emerging technologies and training programs which could apply to the tasks chosen for evaluation. This will include the projected risks and costs of bringing such devices and/or programs to completion.

(04) Obtain information from NASA about training devices and programs which are available and can be used or modified to train the tasks which have been selected for evaluation. Include the cost of operation and modification.

(05) Evaluate the on-orbit work and leisure schedule in order to determine the time available for on-orbit training. Include an estimate of the time required for supervising and/or evaluating the training process.

(06) Elicit expert opinion (via a questionnaire or structured interview) about the advantages or disadvantages of both preflight and on-orbit training. The experts should include members of the NASA training, operations, and astronaut populations.

(07) Review existing algorithms for projecting the cost on-orbit time in dollars per minute. This should include all support costs. Update or refine these algorithms where necessary. Gather data about current preflight training costs.

(08) Conduct a three-day decision conference. Evaluate the costs, benefits and risks of training each of the selected tasks: by location, preflight versus on-orbit; by type, partial on-orbit OJT, cross-task and refresher; and by training time per location. Training device and training program development costs, benefits and risks will be included. The result of the decision conference will be a series of efficiency curves for each of the tasks by all of the parameters.

(09) Perform any further analysis or refinements which might be necessary in order to draw firm conclusions.

(10) Complete the development of and produce the guidelines for evaluating other tasks which might be candidates for preflight versus on-orbit training comparisons.

(11) Produce the final report.

SPECIAL STUDY NEEDS:

TASK(S)	NEED
1,2,3,4	The results of Space Station task analysis, and access to NASA, JSC, training personnel
5,6,8	Access to NASA JSC, training, operations personnel and astronauts.
8	Conference room at NASA, JSC

SPECIAL SKILLS:

TASK(S)	SKILL
1,2,3,4,5,8	Training and training development expertise.
5,6,8	Human Factors Analyst
5,6,8,9,10,11	Decision Analyst

PERFORMING ORGANIZATION:

(01) Managing: NASA, JSC, Training Organization

(02) Doing: Aerospace (Prime)
Consultants, Decision Analysts (Sub)

STUDY PRODUCTS:

(01) A set of guidelines for making decisions about task training locations.

(02) A complete survey of training devices available and of emerging technologies, their potential cost, risk, and benefit.

(03) Training device and training program recommendations for efficient and effective crew training.

PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS:

SUBELEMENT NO. & TITLE		Undefined Rqmt #
30101	Training Methods	-05
30103	Training Location	-02
30104	Training Level (Amount)	-04
30601	Time for Refresher Training	-32
30601	Most Time Effective Training Methods	-33

REPORT FORMAT 15 SCHEDULE-TASK FLOW

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
301M01	ON-ORBIT TRAINING	05-20-85

CALENDAR	1987 O	N	D	1988 J	F	M	A	M	J	J	A	S
FISCAL	FY 88											
MONTH	1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												
STUDY TASKS												
Assuming Mar 88 for PDR:												
1. Selection of tasks for evaluation.								A	-- .5 mm			
2. Literature Review										----	---- 3 mm	----
3. Interview vendors and training developers.											---- 2 mm	----
4. Interview NASA training personnel										B C	---- 2 mm	----

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
301M01	ON-ORBIT TRAINING	05-20-85

	1988			1989								
CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S
FISCAL	FY 89											
MONTH	1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												
STUDY TASKS												
3. (cont.)	--- 1mm											
4. (cont.)	--- 1mm											
5. Evaluate on-orbit work & leisure schedules.	-- .5mm											
6. Administer questionnaires to obtain expert opinions about training location benefits & evaluate.	------------- 4 mm											
7. Review & refine existing algorithms to determine the cost of on-orbit time.		------ 2 mm										
8. Decision conference (3 analysts for 3 days)						-- .5 mm (approx.)						
9. Further analysis							--- 1mm					
10. Complete guidelines								------------- 4mm				
11. Final Report										------ 2mm		

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
301M01	ON-ORBIT TRAINING	05-20-85

SUMMARY SCHEDULE/COST FACTORS

STUDY SPAN: Jun 88-Aug 89 CM = 14

CATEGORY	FACTOR/MM(CM)*	COST $
LABOR		
- NASA Project Mgmt	7.0 mm	
- Study Mgmt	4.0 mm	
- Study Tasks		
- Analyst, Eng'g		
- Special Skills:		
Training/Human Factors Analysts	14.0 mm	
Decision Analysts	9.5 mm	
SPECIAL FACILITIES		
Conference Room at NASA, JSC	3.0 days	
TRAVEL		
1. Inspect training devices, programs and new technologies		5 K
2. To designated location for decision conference		8 K
MATERIALS		None
TEST PROGRAM		None
OTHER (List)		None

* MM = Manmonths; CM = Calendar Months

REPORT FORMAT 13 MANAGEMENT PLAN OVERVIEW

NUMBER	TITLE	DATE
303M01	WALL ACCESS FOR REPAIR PROBLEMS AND OPTIONS	06-22-85

ISSUE #	TITLE	NEED DATE
3030102	WALL ACCESS FOR REPAIR	Nov 85 Aug 86

OBJECTIVES:

(01) Develop and evaluate interior module wall designs that provide accessibility to all inner walls, bulkheads, hatches and seals, facilitating inspection and repairs.

(02) Develop inter-wall design guidelines for equipment arrangement, considering safety precautions (i.e., meteorite protection, fluid flammability/leakage, etc.), accessibility, and repair efficiency.

(03) Devise and evaluate inner module design arrangements that will allow wall accessing and the movement of crewmembers in EVA or IVA suiting and support equipment.

BACKGROUND:

The space station's request for proposal (RFP) specifies that the design shall provide accessibility for walls, bulkheads, hatches and seals for repair and inspection (1). This requirement has not been specifically addressed in supporting documentation such as previous NASA studies. It was addressed in the RFP in order to stress the degree of maintainable design desired. This desired level of maintainability surpasses that specified for Skylab. The demand for wall, bulkhead, hatch and seal access is driven by the low level orbital replaceable unit (ORU) maintenance philosophy and supporting requirements. Wall access for repair has been specified in order to achieve requirements, such as the following:

- Replacement of subsystem equipment shall not require the removal or disconnection of other subsystem equipment nor shall replacement of an equipment module require the removal or disconnection of other equipment modules.

- System design shall provide interfaces that prevent mislocation of equipment modules or intermixing of equipment interface connectors.

- Subsystems equipment shall be removable or replaceable by using installation/handling devices and standardized onboard tool kits. The interconnecting plumbing and wire/cable runs shall have suitable attachment, length, and mounting characteristics to facilitate removal/replacement.

- o As a design goal, all failures or damage (including structural) shall be repairable.

- o Adequate clearance shall be provided during the removal or replacement of equipment undergoing maintenance in order to preclude any interference with other Space Station operations and to preclude the creation of any safety hazard.

While it is generally acknowledged that the wall access design features can have a significant effect on human performance, the maintenance philosophy, and overall space station design, a clear cut specification of interior wall design guidelines cannot be developed without a detailed study of the specific space station hardware, configuration and mission needs.

The present issue resolution managment plan provides a technical approach for developing wall accessibility guidelines and designs. It also addresses the inner-wall equipment arrangement which must facilitate accessibility, maintenance actions, and safety. In addition, the plan will address the interior module space required during wall accessing for crew members, dressed for either EVA or IVA adaptation, and support equipment in a zero-g environment.

This plan will be conducted in two segments. The first segment will be completed at SRR, establishing wall accessibility guidelines and a selection of wall accessing designs. Figure 1, 2, and 3 are examples of accessability designs, providing an indication of the type of accessing resolutions which this plan is striving for. These guidelines and designs will be developed through multi-company space station senior designer input meetings. The guidelines and designs will be compiled, establishing a data base of wall access design requirements and the most optimal wall design concepts. The requirements and design concepts will be further refined to establish the optimal wall accessing design during the second study phase, for impact at SDR. This second phase will require extensive literature research, prototype simulation, structural surveys, and designer evaluations in order to select the optimal wall access design concept.

<u>INPUTS</u>:

A. Compartment arrangements & volume guidelines (Mgmt. Plan 101M01)
B. Level of Orbital Replaceable Unit (ORU) repair
C. Interior Volume Modularity/Rearrangement (Mgmt. Plan 106M01)
D. Mission requirements/hardware demands
E. Hardware/equipment type selection
F. Module structural design
G. Safety requirements/guidelines for structural and equipment configuration
H. Habitable volume leak point (Mgmt. Plan 218M04)

<u>CRITICAL ASSUMPTIONS</u>:

(01) All walls can be accessed by all crew members with the anthropometric limits specified in the RFP.

(02) A full scale, zero-g simulation (i.e., neutral bouyancy tank) will be performed in evaluating the optimal wall access design.

(03) It is assumed that SRR will be held during March 1986.

(04) It is assumed that SDR will be held during November 1986.

SPECIAL REMARKS:

(01) The wall accessing plan is broken down into two segments: (1) establishing guidelines and possible design approaches; and (2) development of the optimal access design and guidelines based upon the first segments input. The first segment will establish a data base of guidelines and design approaches supplied by senior designers over the short period prior to SRR. Due to the limited time prior to SRR, extensive literature research, evaluations, and optimal refinement will be conducted after SRR and will be concluded for impact at SDR.

(02) The accessibility designs developed will be dependent on the results of management plan 101M01, compartment arrangement and volume guidelines or similar information. An interrelationship between these two studies must be established to exchange concepts so that a parallel design effort can be conducted.

(03) The space station hardware must meet structural guidelines, and supporting issues must be integrated or established prior to the accessibility plans initiation so that accurate design concepts and guidelines are developed.

(04) The layout of equipment on the module interior panels is not an issue for this study, but the manner in which equipment is supported by inner wall, cabling, racks, etc., is.

(05) The wall accessing configuration must be designed with the consideration that an unpressurized or pressurized environment is in existance within the module requiring repair. This implies that accessability must conform to crew members in EVA or IVA attire and related support equipment.

REFERENCES:

(01) NASA, Space Station Definition & Preliminary Design, Request for Proposal, Solicitation #9-BF-10-4-01P, Sep 1984, pp. C-4-19

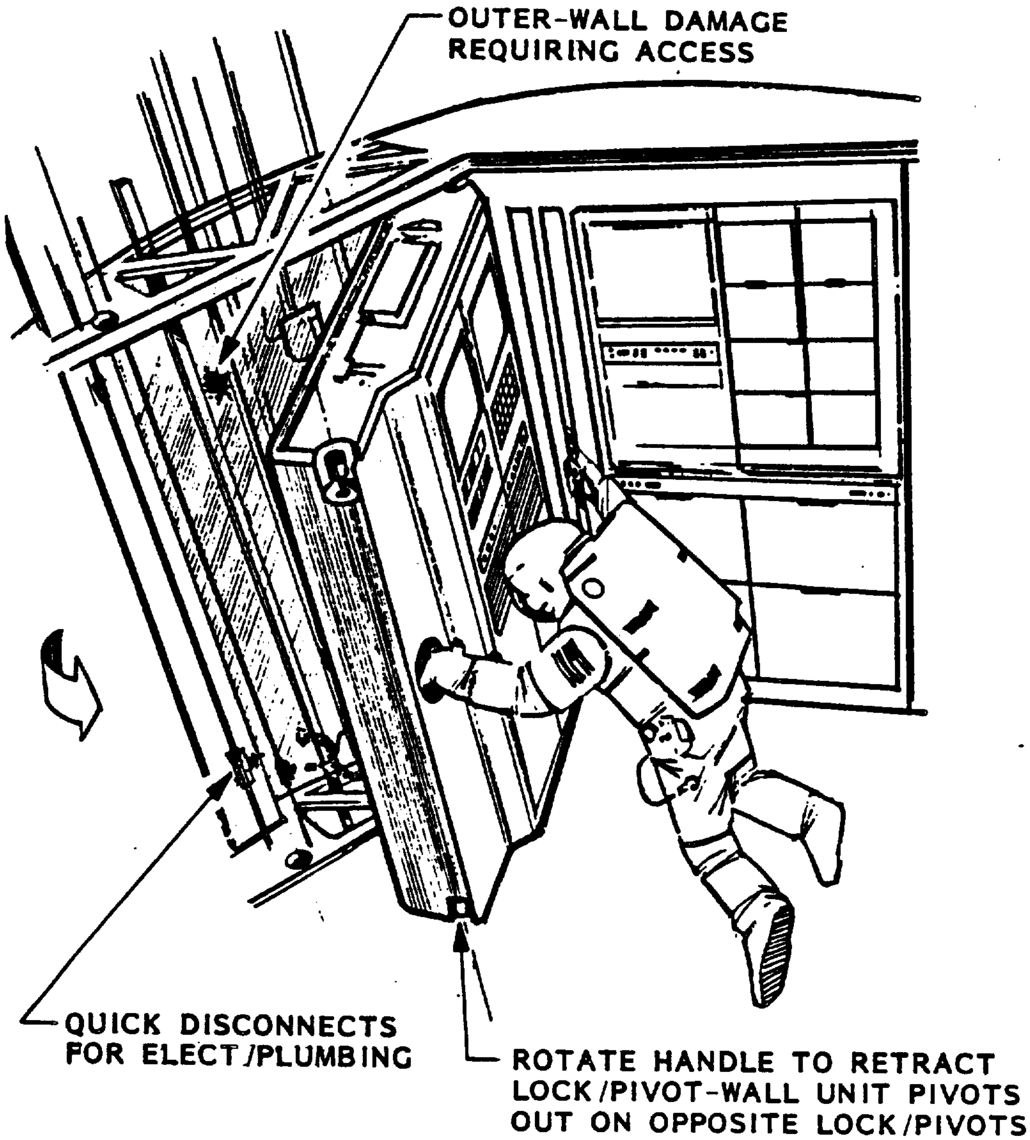

FIGURE 1 WALL DAMAGE REQUIRING ACCESS FOR REPAIR

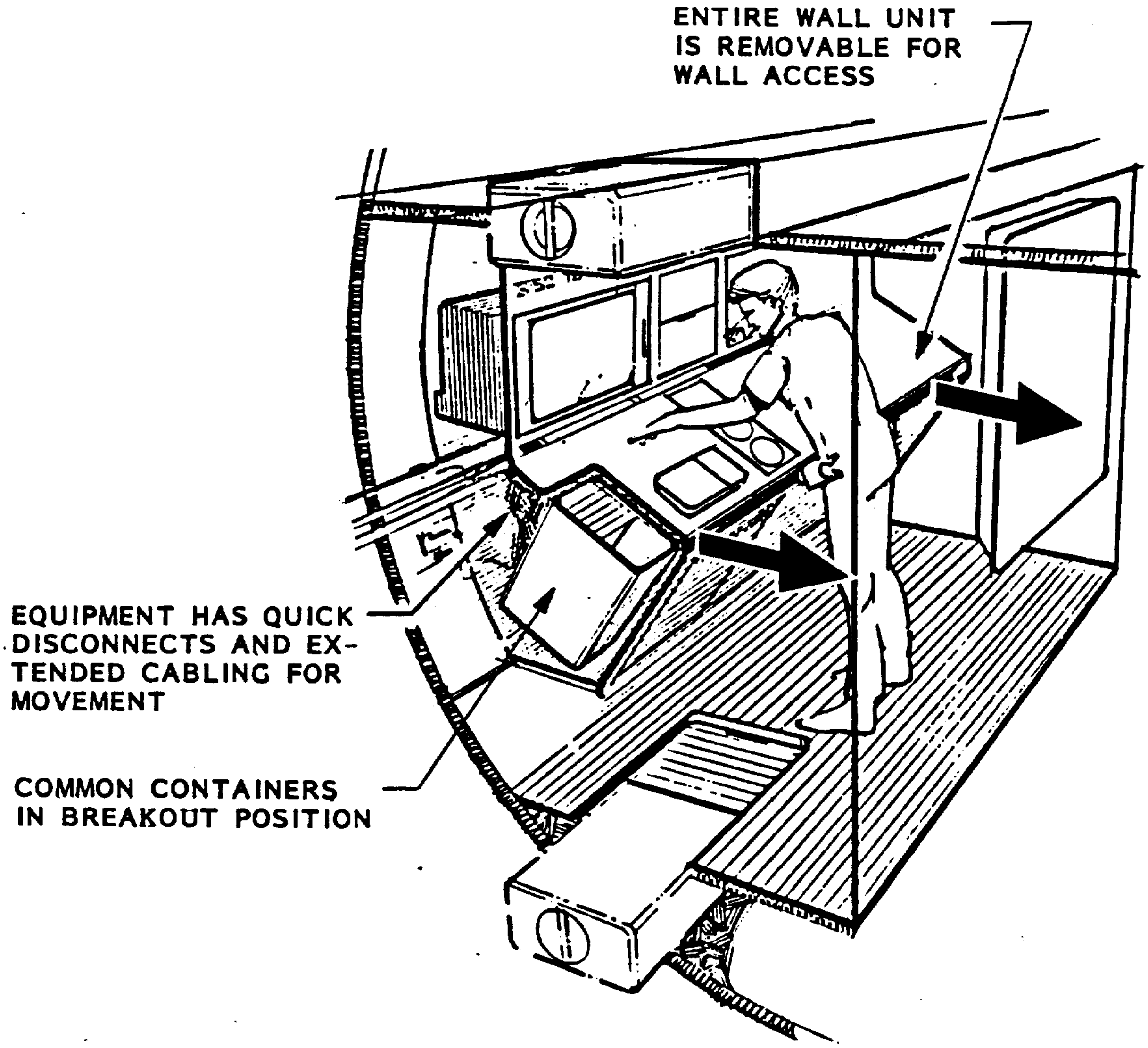

FIGURE 2 WALL UNITS WHICH MOVE

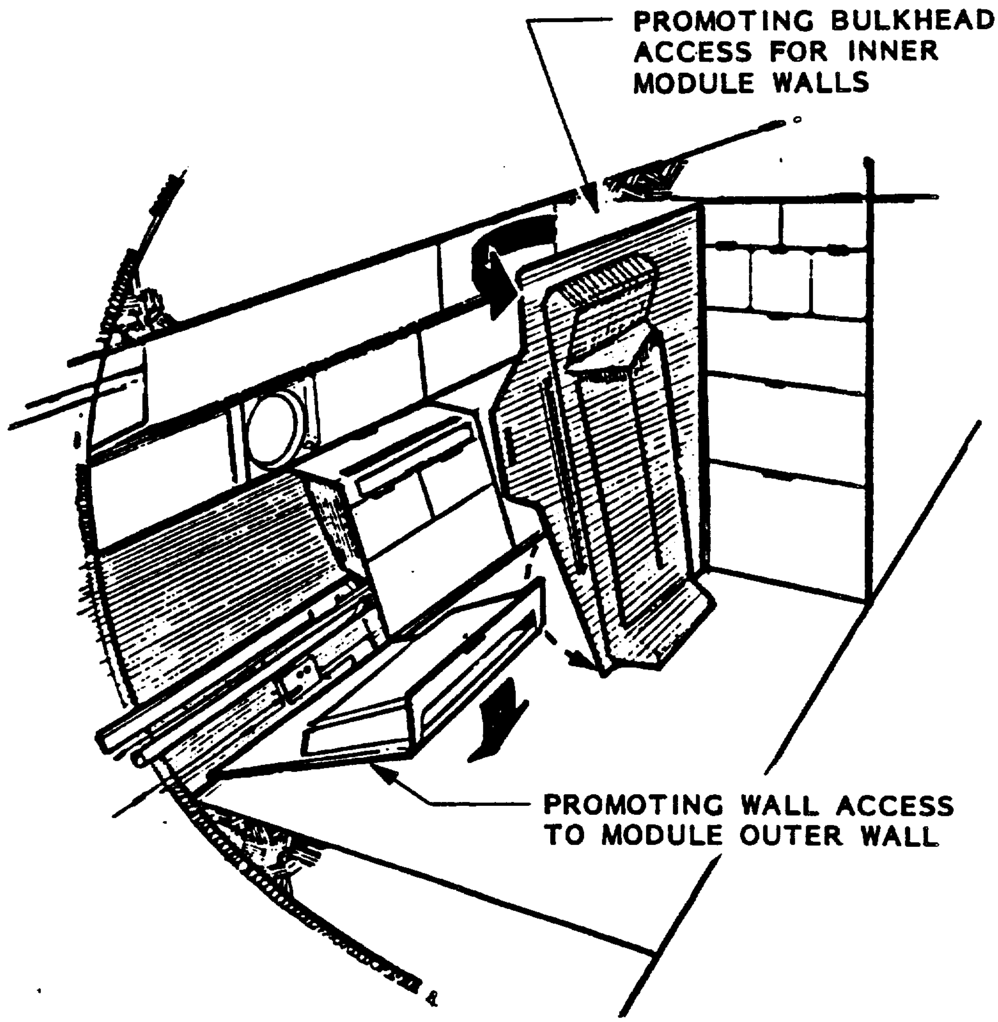

FIGURE 3 BULKHEAD AND OUTER-MODULE WALL ACCESSING

REPORT FORMAT 14 STUDY PLAN

NUMBER	TITLE	DATE
303M01	WALL ACCESS FOR REPAIR PROBLEMS AND OPTIONS	06-22-85

STUDY TASKS:

The study will be divided into two segments. Each segment is comprised of individual tasks:

SEGMENT 1

(01) Develop a data bank of suggested guidelines pertaining to wall accessible design, required operations for access, and internal wall equipment arrangement and support characteristics. Data bank development shall result from questioning senior design and systems engineering personnel who are actively participating in space station module design.

(02) Refine the established guideline data base into a listing of design guidelines and requirements to be used during the SRR time phase.

(03) Compile a library of potential accessibility design concepts for wall, bulkhead, hatch and seal inspection and repair. Design and systems engineers active in module development shall participate in the development of these design concepts.

(04) From the proposed accessibility library of concepts compile the top designs which are viewed as the most cost-effective and efficient for additional study after SRR.

SEGMENT 2

(05) Conduct literature reviews of accessibility design concepts, required operations for access, and inter-wall arrangement and support characteristics, to add to and refine the established list of guidelines and requirements presented at SRR.

(06) Perform a detailed analysis of each of the proposed wall access design concepts presented at SRR. The analysis should conclude with the selection of design concepts for mock-up and simulation for final evaluation and optimal design selection.

(07) Develop full scale mock-ups of the candidate wall access design concepts to verify and evaluate the design quality for optimal design selection through simulation. Develop a structured interview format as a means of obtaining consistent evaluation data from the population which will perform during the simulation.

(08) Perform a simulation of candidate design concepts in a zero-g environment in order to obtain the evaluation data from test subjects. The test subjects should be comprised of crew members, former, present and future. The simulation and data evaluation will conclude the optimal design selection process.

SPECIAL STUDY NEEDS:

TASK(S)	NEED
1,3	Access to design & systems engineers who are participating in module development for questioning and NASA experts.
5,6	Availability of space station configuration data, structural design data & compartment arrangement guidelines.
7,8	Model-making capability.
8	Simulation support capabilities (i.e., neutral bouyancy, Space Shuttle).
8	Access to the candidate crew population and NASA experts.

SPECIAL SKILLS:

TASK(S)	SKILL
7,8	Industrial designer
1,2,3,4,5,6,8	Maintainability Engineer
1,3,6	Systems and design engineering specialists
8	Crew populations and NASA experts

PERFORMING ORGANIZATION:

(01) Managing organization: NASA Laboratories

(02) Doing Organizations: Aerospace Firm (Prime)
Industrial Design Firms (Sub)

STUDY PRODUCTS:

Detailed design specifications for:

(01) Space Station interior wall design features for accessing inner walls, bulkheads, hatches and seals in terms of repair and inspection.

(02) Design features for inner equipment wall arrangement, for safety, accessibility, and repair efficiency.

(03) Design features for accessing that will allow for interior module crew and support equipment movement during wall accessing.

PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS:

SUBELEMENT NO. & TITLE	Undefined Rqmt #
30301 Accessibility	-08

REPORT FORMAT 15 — SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
303M01	WALL ACCESS FOR REPAIR PROBLEMS AND OPTIONS	06-22-85

	1984			1985								
CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S
FISCAL	FY 85											
MONTH	1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												

STUDY TASKS

Assuming that SRR is March 1986 & SDR is November 1986.

SEGMENT No. 1

1. SS Design guidelines data-gathering.	B -- D E F G
3. SS Design Concepts	--

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
303M01	WALL ACCESS FOR REPAIR PROBLEMS AND OPTIONS	06-22-85

	1985			1986								
CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S
FISCAL	FY 86											
MONTH	1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												

STUDY TASKS		
SEGMENT No. 1		
1. (cont.)	---	1.5mm
2. Refinement of data-gathered	--	.5mm
3. (cont.)	---	1.5mm
4. Refinement of design concepts	--	.5mm
SEGMENT No. 2		
5. Literature research for guidelines & refinement	A C H -------------------------	8.5mm
6. SS Design Concept Analysis	-----------------	5.5mm
7. Full scale mockup development	------	2mm
8. Zero-g simulation evaluation	---	1mm
	TOTAL mm = 21.0 mm	

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
303M01	WALL ACCESS FOR REPAIR PROBLEMS AND OPTIONS	06-22-85

SUMMARY SCHEDULE/COST FACTORS

STUDY SPAN: Sep 85-Jul 86 CM = 11

CATEGORY	FACTOR/MM(CM)*	COST $
LABOR		
- NASA Project Mgmt		
- Study Mgmt	7 MM	
- Study Tasks		
- Analyst, Eng'g		
- Special Skills:		
Maintainability Eng'g	2 MM	
Design & Systems Eng'g	15 MM	
Ind. Design	2 MM	
	2 MM	
SPECIAL FACILITIES		
Zero-g simulation (i.e., neutral bouyancy tank, space suits)	1 wk	
TRAVEL		
Coordination w/NASA, Aerospace Co's.		15 K
MATERIALS		
Mockup Fabrication		10 K
TEST PROGRAM		
Astronaut test subjects for mockup evaluation		10 K
OTHER (List)		

* MM = Manmonths; CM = Calendar Months

REPORT FORMAT 13 MANAGEMENT PLAN OVERVIEW

NUMBER	TITLE	DATE
306M01	CREW SCHEDULES	07-16-85

ISSUE #	TITLE	NEED DATE
3060301	FACTORS FOR WORK SCHEDULING	MAR 86
3060103	MISSION LENGTH REQUIREMENT	MAR 86
3060102	SHIFT OPTIONS	MAR 86
3060104	VARIED CREW SCHEDULE MODELS	MAR 86
3060106	REC/LEISURE TIME REQUIREMENTS	MAR 86
3060108	REST BREAK REQUIREMENTS	MAR 86
3060111	SHIFT EFFECTS ON PERFORMANCE	MAR 86

OBJECTIVES:

(01) Identify scheduling considerations and factors which affect crew performance and satisfaction.

(02) Determine maximum length of mission considering psychological, physiological and system factors.

(03) Determine the effects of shift work on motivation, fatigue and error rates. Identify the shift options which are most conducive to system productivity and crew satisfaction.

(04) Determine the most effective activity schedule for various mission durations.

(05) Determine the optimum frequency and duration of rest breaks to provide maximum productivity.

(06) Determine the time needed for exercise, rest, recreation, and pre- and post-sleep, etc. to maintain health, motivation and alertness for different types people for different mission lengths.

(07) Determine the responsibility, scope, methods and requirements for a "shopping list" of tasks for optional or contingent inclusion in crew schedules.

(08) Determine methods for establishing task weighting factors.

(09) Develop methods for translating global planning into the on-board scheduling system.

(10) Develop methods for incorporation of individual crew interests, habits, skills, etc. into on-board scheduling system.

(11) Develop categorization (nomenclature) scheme to be used in the scheduling system for specifying tasks, space craft systems, crew skills, experience levels, etc.

BACKGROUND:

It is common experience that the circumstances surrounding human activity affect the efficiency and effectiveness with which it is performed. Given the effort expended in placing personnel in orbit, it is mandatory to optimize their performance effectiveness while they are there. While it is conceded that activity planning and scheduling can enhance performance effectiveness, the specific planning and scheduling considerations and other factors which are important contributors to effective and efficient performance are not well known. Further, what is known in this area is largely limited to a terrestrial context in which non-work activities play an uncontrolled and undetermined role in work performance.

The substantially closed environnment of the Space Station enables a greater degree of control of relevant variables than is characteristic of conventional earth-bound production activity. At present, knowledge of these variables is not commensurate with their anticipated importance. The fact that these variables are left to chance in a conventional work environment reflects lack of control, not lack of importance.

This issue resolution management plan provides the basis for identification of performance relevant schedule factors and development of planning and scheduling criteria and specifications. While some of the factors expected to be important scheduling considerations have been identified, a complete listing has not been made. The relative importance of impact of the factors as well as any interactive effects have not been determined. Until this data is defined, it will not be possible to determine what task weighting variables to apply in developing balanced task loading.

Resolution of these concerns are considered critical. Because of the assessed need date of March 86, the described approach requires resolution by a convened panel of experts in lieu of lengthier analytic approaches.

INPUTS:

A. System constraints on planning/scheduling flexibility.
B. Human endurance (work).
C. Crew composition (age, sex, condition).
D. Task characteristics, e.g., difficulty, length/complexity, payoff value.
E. Stress load (e.g., noise, lighting, adequacy, vibration, air quality, etc.).
F. Facilities available for recreation and leisure activities.
G. Sound/vibration control effectiveness relative to crew rest/sleep.

CRITICAL ASSUMPTIONS:

(01) Resolution is needed by March 1986.

(02) A task force can be convened to accomplish the stated objectives.

(03) Assumptions will be made in lieu of non-available Input data requirements.

(04) SRR will occur in March 1986.

SPECIAL REMARKS:

(01) The results of this study will be critical in supporting definition of the overall system design requirements. The scheduling parameters will drive the design of the payload and housekeeping crew interface definition. Crew size definition hinges on specification of crew scheduling constraints.

(02) Due to the critical nature of this study, a task force approach is recommended. This task force should be composed of NASA, industry, and acadamic crew systems experts. This task force needs to be co-located. The task force needs to complete the crew schedule specifications by March of 1986 in order to support the Phase B schedule.

(03) Although the parameters of concern to this study are those common to all personnel, it is recognized that individual differences in work history and/or related experience may require individual tailoring of the activity schedules.

REFERENCES:

(01) Soviet Space Station Analogs, Boeing Aerospace Co., D180-28182-1, Oct 83

(02) Space Station Habitibility Report, Boeing Aerospace Co., NASW-36801/CC0081, Feb 83

(03) Space Station Nuclear Submarine Analog, Boeing Aerospace Co., D180-28181-1, Oct 83

REPORT FORMAT 14 STUDY PLAN

NUMBER	TITLE	DATE
306M01	CREW SCHEDULES	07-16-85

STUDY TASKS:

(01) Review Literature - Review literature to establish the pertinent general and specific factors to be considered in planning and scheduling crew activities. Review planning/scheduling practices of other long term isolated group operations such as submarine, Antarctic, etc. Consult with NASA and academic experts.

A number of factors have already been identified, as indicated by the list of objectives for this study. However, there are expected to be numerous others that impact personnel performance, both individually and in interaction with other factors. This task will focus on development of an exhaustive listing of factors and factor combinations which will have impacts on personnel scheduling.

(02) Evaluate Performance Impacts of Scheduling Factors - Evaluate the impacts of scheduling factors identified in Task 01 (e.g., length of mission, shift work, activity schedule, autonomy, etc.) relative to performance (e.g. error rates motivation/emotional well-being, fatigue, physical health and conditioning, etc.). Include evaluation of the effects of environmental factors (e.g. zero-g) and task characteristics (e.g. lab work, construction work, maintenance work, etc.).

(03) Define Other Scheduling Constraints - This task will include analysis of the following schedule selection factors:

a. Payload requirements and objectives constraints on crew scheduling options (e.g., astronomical observations need to be conducted when the Station is in a specified orbital location regardless of the time of day)
b. Definition of the methods for incorporating optional crew activities (i.e.,"shopping list") into daily schedules.
c. Methods for establishing task "weighting" factors (i.e., some jobs are easy and others are intense) into the schedule definition.
d. Methods for incorporating "global" planning constraints (e.g., planned maintenance, crew rotation, etc.) into detailed crew scheduling.
e. Definition of the nomenclature to be used in defining the scheduling parameters.

(04) Define Crew Schedule Specifications - From the results of Tasks 01 and 02, formulate the specifications for Space Station crew scheduling factors: mission lengths, shift options, rest breaks, recreation and leisure scheduling parameters, etc. This specification shall also include definition of the methods for taking into account the operational and system constraints defined in Task 03.

SPECIAL STUDY NEEDS:

TASK(S)	NEED
	None identified

SPECIAL SKILLS:

TASK(S)	SKILL
1,2,3,4	Human factors specialist, physiologist, social-psychologist, mission planning specialist, industrial health specialist

PERFORMING ORGANIZATION:

(01) Managing: NASA-Ames (Space Human Factors)

(02) Doing: Aerospace Firm (Prime)

(03) Consultants: University, e.g., Univ. of Texas

STUDY PRODUCTS:

Detailed specification and criteria for Space Station personnel planning and scheduling including:

(01) Maximum length of mission.

(02) Acceptable shift options.

(03) Degree of Space Station planning and scheduling autonomy.

(04) Frequency and duration of rest breaks, recreation, leisure, etc.

(05) Variations of parameters 2 thru 4 for different length missions.

PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS:

SUBELEMENT NO. & TITLE	Undefined Rqmt #
30603 SCHEDULING METHODS	-07,-10,-12,-16,-25,
30601 DUTY CYCLES	-02,-07,-09,-13,-19, -26,-28,-30,-34

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
306M01	CREW SCHEDULES	07-16-85

```
                                          1985       |     1986                         |
                                 CALENDAR|O--N--D--|J--F--M--A--M--J--J--A--S|
                                   FISCAL|FY 86                                       |
                                    MONTH|1  2  3   4  5  6  7  8  9 10 11 12|
                                  PHASE B|                                             |
                                        C|                                             |
STUDY  TASKS                             |                                             |
Assumes SRR in Mar 86                    |B                                            |
1. Review Literature                     |------                                       |
                                         |(6 mm)                                       |
                                         |   C                                         |
                                         |   E                                         |
                                         |   F                                         |
2. Evaluate Performance Impacts          |   G--------                                 |
   of Scheduling Factors                 |     (10 mm)                                 |
                                         |A                                            |
3. Define Other Scheduling               |D-------------                               |
   Constraints                           |    (8 mm)                                   |
                                         |                                             |
4. Define Crew Schedule Specifi-         |          -------                            |
   cations.                              |          (4 mm)                             |
                                         |                                             |
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REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
306M01	CREW SCHEDULES	07-16-85

SUMMARY SCHEDULE/COST FACTORS

STUDY SPAN: OCT 85-MAR 86 CM = 5

CATEGORY	FACTOR/MM(CM)*	COST $
LABOR		
- NASA Project Mgmt	5 mm	
- Study Mgmt	5 mm	
- Study Tasks		
- Analyst, Eng'g.		
- Special Skills:		
- Human Factors	22 m/m	
- Consultants	6 m/m	
-Physiologist		
-Social Psychologist		
-Mission Planning Specialist		
-Industrial Health Specialist		
SPECIAL FACILITIES		
TRAVEL		
Expert travel to JSC		20 K
Visit analog work sites		10 K
MATERIALS		
TEST PROGRAM		
OTHER (List)		

* MM = Manmonths; CM = Calendar Months

REPORT FORMAT 13 MANAGEMENT PLAN OVERVIEW

NUMBER	TITLE	DATE
306M02	DEVELOP EXPERT SCHEDULING SYSTEM REQUIREMENTS	07-16-85

ISSUE #	TITLE	NEED DATE
3060302	DEVELOP EXPERT SCHEDULING SYSTEM REQUIREMENTS	JUL 87

OBJECTIVES:

(01) Develop requirements for a user friendly, AI/expert system-based system for planning and scheduling crew activities.

BACKGROUND:

Planning and scheduling will apply to all phases of Space Station operations. Examples include the following:

- o Scheduling crew activities
- o Planning complex maintenance operations
- o Scheduling resource usage
- o Planning for an orbiter rendezvous

Conventional planning software systems use algorithms designed to produce optimal plans. Unfortunately, it is often the case that the use of these systems is prohibitively expensive when applied to complex problems. An alternative approach is to develop planning systems that emulate human planners. Humans generally do not attempt to develop optimal plans. They attempt to define satisfactory plans, i.e., plans that are "good enough". They do this by applying planning heuristics, exercising judgement, and employing knowledge about the planning domain. Artificial Intelligence (AI) provides techniques that permit emulation of these characteristics of human planners. For this reason, AI shows promise as a technique for solving complex planning problems.

The planning system "Deviser" exemplifies the current state of the art for AI planning systems (Reference 1). It is a working prototype that plans and schedules actions for an unmanned spacecraft such as Voyager. It solves a problem for which there is no known feasible algorithmic solution. It has a limited ability to reason about time. It is slow but still is 10 to 50 times faster than a human.

Deviser lacks many capabilities needed by a general planning system. Examples include the following:

- o Cannot plan under uncertainty
- o Cannot plan in presence of potentially uncooperative entities
- o Does not monitor execution of plans to detect need for replanning

The present issue resolution management plan provides a technical approach for developing specifications for an expert scheduling system. The approach is to develop a prototype based on existing AI planning technology. This approach permits the determination of those functions which may feasibly be allocated to a planning system. It permits an estimation of the user time which will be required and of the impact on operations. Finally it permits evaluation of concepts concerning ground versus station roles and the input to and access of scheduling protocols.

INPUTS:

A. Data on existing AI planning systems.

CRITICAL ASSUMPTIONS:

(01) The Space Station scheduling problem is sufficiently complex that conventional algorithmic solutions are not feasible.

(02) An existing AI planning system will serve as a satisfactory basis for a prototype.

SPECIAL REMARKS:

(01) Planning systems with a capability to learn are not expected to be developed before the year 2000. For this reason, learning will not be considered.

(02) Crew schedules are expected to have a significant impact on Space Station subsystem management. For this reason, it is recommended that this study be extended to consider the interaction of crew scheduling with subsystem management.

(03) Minimizing crew workload associated with using the scheduling system is a primary consideration.

REFERENCES:

(01) S. A. Vere, "Deviser: An AI Planner for Spacecraft Applications," Aerospace America, Apr 1985, pp. 50-53.

REPORT FORMAT 14 STUDY PLAN

NUMBER	TITLE	DATE
306M02	DEVELOP EXPERT SCHEDULING SYSTEM REQUIREMENTS	07-16-85

STUDY TASKS:

01) Define Scheduling System Requirements - Develop a detailed specification of the requirements for the expert scheduling system. Requirements to be defined include the following:

- o Parameters required for a "user friendly" computer interface taking into account the crew skills.
- o The amount of time required/available for user inputs to the scheduling system.
- o Weighting factors to compensate for task loading for a set of tasks in a given scheduling interval.
- o Methods for incorporating feedback on learning curves, experience, and improvements in skill.
- o Protocols for ground input and access to the on-board scheduling system.

(02) Develop Typical Scheduling Scenarios - Develop typical crew activity scheduling problems. Determine tasks to be performed, constraints on the scheduling tasks, and measures of schedule goodness. Provide results to Task 1 analysis.

(03) Survey AI-based Planning Systems - Survey existing AI-based planning systems to determine domain of applicability of each system to the requirements defined in Task 01. Establish typical computational requirements of each system. Consult with planning specialists in AI research laboratories.

(04) Develop Planning System Concept - Select baseline planning system by comparing Task 01 requirements and Task 03 system evaluations. Develop a method for user input, user interaction, and display of results. Propose an allocation of functions between users and system.

(05) Develop Prototype Planning System - Acquire the hardware and software for the AI-based planning system selected in Task 04. Develop the scheduling test case database. Develop user interface software. Repackage hardware (if necessary) to simulate Space Station installation.

(06) Evaluate the Prototype Planning System - Make final timing, sizing, interface estimates. Determine user time required and impact on operations. Determine shortfall between what is technically feasible and what is desired.

(07) Estimate Phase C Requirements - Make preliminary sizing, timing, and interface estimates. These results are intended to facilitate establishing hardware requirements for Phase C.

(08) Prepare Operational Planning System Specification - Integrate the results of Tasks 1, 2, 3, 4, 6 and 7. From this, define the specifications for the operational planning system.

SPECIAL STUDY NEEDS:

TASK(S)	NEED
3,5,6,7	Access to AI laboratory

SPECIAL SKILLS:

TASK(S)	SKILL
1,3,4,5,6,7	AI Planning Experts
1,4,5,6,7	Software/knowledge Engineering Expert
1,4,6	Human Factors Specialist
1,2	Mission Operations Planner

PERFORMING ORGANIZATION:

(01) Managing: NASA-JSC, AI Laboratories

(02) Doing: Aerospace Contractor (Prime)
AI Laboratories (Sub)

STUDY PRODUCTS:

Expert scheduling system specifications document

Prototype expert scheduling system

PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS:

SUBELEMENT NO. & TITLE	Undefined Rqmt #
30603 SCHEDULING METHODS	-02,-11,-15, -17,-19,-22

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
306M02	DEVELOP EXPERT SCHEDULING SYSTEM REQUIREMENTS	07-16-85

```
                                           1985       |    1986                        |
                                   CALENDAR|O--N--D--|J--F--M--A--M--J--J--A--S|
                                     FISCAL|FY 86                                   |
                                      MONTH|1  2  3   4  5  6  7  8  9 10 11 12|
                                    PHASE B|                                        |
                                          C|                                        |
STUDY   TASKS                              |                                        |
1. Define Scheduling System Require-       |------                                  |
   ments                                   |(4 mm)                                  |
                                           |                                        |
2. Develop Typical Scheduling              |------                                  |
   Scenarios                               |(2 mm)                                  |
                                           |A                                       |
3. Survey AI-Based Planning Systems        |------                                  |
                                           |(2 mm)                                  |
4. Develop Planning System Concept         |      ----------------                  |
                                           |         (8 mm)                         |
5. Develop Prototype Planning System       |                      -------------|
                                           |                         (12 mm)        |
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REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
306M02	DEVELOP EXPERT SCHEDULING SYSTEM REQUIREMENTS	07-16-85

	1986			1987								
CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S
FISCAL	FY 87											
MONTH	1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												
STUDY TASKS												
5. (cont)	---											
6. Evaluate Prototype Planning System		----	---- (4 mm)	----	----							
7. Estimate Phase C Requirements						----	---- (2 mm)					
8. Prepare Operational Planning System Specification								----	---- (2 mm)			

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
306M02	DEVELOP EXPERT SCHEDULING SYSTEM REQUIREMENTS	07-16-85

SUMMARY SCHEDULE/COST FACTORS

STUDY SPAN: Oct 85-Jul 87 CM =22

CATEGORY	FACTOR/MM(CM)*	COST $
LABOR		
- NASA Project Mgmt		
- Study Mgmt	5 mm	
- Study Tasks		
- Analyst, Eng'g	13.5 mm	
- Special Skills:		
-Human Factors	5 m	
-AI Planning	7.5 m	
-Knowledge Engineering	10 m	
SPECIAL FACILITIES		
- AI Laboratory	9 cm	
TRAVEL		
- Coordination with NASA, Aerospace Companies, Subcontractors		15 K
MATERIALS		
- Baseline planning system		15 K
TEST PROGRAM		
OTHER (List)		

* MM = Manmonths; CM = Calendar Months

REPORT FORMAT 13 MANAGEMENT PLAN OVERVIEW

NUMBER	TITLE	DATE
306M03	IVA/EVA TASKS AND LEARNING CURVES	07-16-85

ISSUE #	TITLE	NEED DATE
3060101	IVA/EVA TASKS AND LEARNING CURVES	OCT 85,86, 87,88,89
3060105	TASK PERFORMANCE ANALYSIS	OCT 85,86 87,88,89

OBJECTIVES:

(01) Define an average time for Space Station task activities (IVA and EVA).

(02) Determine what the" learning curve" is for the various tasks.

(03) Compile "lessons learned" data for specific operations which will be performed on the Space Station.

BACKGROUND:

In the operations analysis and planning for the on-orbit activities to be performed by the crew, it is necessary to define detailed task timelines. The human engineers who perform these analyses have obtained task execution times from 1-g simulations, neutral bouyancy tests, and Skylab experience. The Human Role in Space (THURIS) study (Ref. 1) has compiled task performance times gathered from these sources for 37 generic tasks. However, with routine STS flights, it is now feasible to compile a much larger data base of actual zero-g task performance times. By analyzing videotapes of astronauts performing a wide variety of IVA and EVA tasks, a vast amount of task time data can be compiled.

Analysis of videotapes of on-orbit IVA and EVA tasks will also yield valuable "learning curve" data. Learning curves indicates that the task execution times decrease after an activity has been performed a number of times. This task learning curve will depend on the complexity of the task and the individual performing it. At some point the execution time will level off so that it will be fairly consistent from then on. For specific crewmembers, it will be feasible to compare on-orbit task execution times to those observed during mission training. In addition, if some of the tasks are repeated by a crewmember during a mission, it will be feasible to compare task execution times for each repitition. Accumulation of this task learning curve data will provide mission planners and the expert scheduling system with the capability to be much more precise in laying out timelines for repeated tasks.

This proposed study will be a multi-year effort that will start by collecting task time data from STS flights and could continue on into the Space Station operational era collecting the same kinds of data.

INPUTS:

A. IVA video tapes from Space Shuttle missions.
B. EVA video tapes from Space Shuttle missions.
C. Various Space Station crew tasks.

CRITICAL ASSUMPTIONS:

(01) None

SPECIAL REMARKS:

(01) The proposed approach for this study is to acquire the task time data by analyzing videotapes of on-orbit tasks. Manual viewing, deciphering, recording, and sorting is a limiting factor of this study. Most of the record keeping could be done manually, however, due to the large amount of data to be handled, it could be done faster and with more economy if done with computers.

(02) Due to the quantity of videotapes to be analyzed, there will be a need for a team of people to view the tapes for comparison of activity times. There is a matter of concern in using a team to record various activities. Unless one person is assigned to view certain activities, there will be some variation from person to person as to when an activity actually begins and ends. The study should be set up with certain standards so that more than one individual can view a situation and come up with a similar conclusion from a video taped activity.

(03) A valuable by-product of this video tape analysis will be the capability to document lessons learned from observing the IVA and EVA operations. These "lessons learned" are observaions of what worked right, what difficulties were encountered, and what did not work at all. Conditions which are conducive to error relative to different types and sequences of tasks can be ascertained from these observations. These are very valuable insights that designers and ops analysis experts need to know.

(04) This task should be an on-going project that will extend into IOC. This study plan requires a periodic (once a year) documentation.

(05) Refer to Ref. 2 for an example of how this kind of study can be conducted and the type of study products which can be obtained.

REFERENCES:

(01) The Human Role in Space Study, Contract NAS8-35611, McDonnell Douglas Astronautics Co., MDC H1295, Oct 1984.

(02) Video Tape Review of EVA Activity on Space Shuttle Missions STS-6/STS-11/STS-13, T. A. Donohue for Boeing Aerospace Co., D180-28421-1, 5 Nov 1984

REPORT FORMAT 14 STUDY PLAN

NUMBER	TITLE	DATE
306M03	IVA/EVA TASKS AND LEARNING CURVES	07-16-85

STUDY TASKS:

(01) Review Videotapes - Review available video tapes of IVA/EVA tasks. Observe and record task execution times for the various crew activities. Record the task executing data with identification of the performing crewmember. From the accumulated data compute an average task execution time. Compute learning curves for each crewmember. Compile a task catalog. Compare the catalog of observed IVA and EVA tasks against the planned Space Station tasks to identify voids in the task time database.

(02) Conduct Task Timeline Experiments - Define flight experiments required to collect task data to fill in data gaps identified in Task 01. Conduct various STS experiments designed to parallel certain activities which will be performed on Space Station so that data can be collected for time studies.

(03) Document Lessons Learned - Document lessons learned regarding the active use of tools, devices, and accessories. Define conditions which are conducive to error relative to different types and sequences of tasks.

SPECIAL STUDY NEEDS:

TASK(S)	NEED
1,3	Access to video tapes of IVA/EVA tasks on previous STS missions.
1,3	Videotape laboratory equipped with videotape monitoring equipment and computer terminals for inputting and retreiving data.
2	STS flight experiments designed to simulate selected Space Station activities

SPECIAL SKILLS:

TASK(S)	SKILL
1,2,3	Crew systems analysts
1	Engineering technical aides

PERFORMING ORGANIZATION:

(01) Managing: NASA/JSC Manned Systems Division

(02) Doing: Aerospace Contractor (Prime)

STUDY PRODUCTS:

(01) A task catalog with task times and learning curves.

(02) A "lessons learned" document.

PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS:

SUBELEMENT NO. & TITLE	Undefined Rqmt #
30601 DUTY CYCLES	-01,-27

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
306M03	IVA/EVA TASKS AND LEARNING CURVES	07-16-85

```
                                         1985         |    1986                                 |
                                CALENDAR|O--N--D--|J--F--M--A--M--J--J--A--S|
                                  FISCAL|FY 86                                                    |
                                   MONTH|1   2   3    4   5   6   7   8   9  10  11  12|
                                 PHASE B|                                                          |
                                       C|                                                          |
STUDY  TASKS                             |     Data Gaps             Report No. 1|
                                        |A                                                         |
                                        |B                                                         |
                                        |C                                                         |
1. Review Videotapes                    |---------^-------------------------^|
                                        |                    (12 mm)                              |
2. Conduct Task Timeline Experiments    |            --------------------------|
                                        |                       (9 mm)                            |
                                        |                          Report No. 1|
3. Document Lessons Learned             |--------------------------------------^|
                                        |                    (12 mm)                              |
```

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
306M03	IVA/EVA TASKS AND LEARNING CURVES	07-16-85

```
                                  1986          ¦    1987                          ¦
                         CALENDAR¦O--N--D--¦J--F--M--A--M--J--J--A--S¦
                           FISCAL¦FY 87                                            ¦
                            MONTH¦1   2   3    4   5   6   7   8   9  10  11  12¦
                          PHASE B¦                                                 ¦
                                C¦                                                 ¦
STUDY   TASKS                    ¦                               Report No. 2¦
                                 ¦A                                                ¦
                                 ¦B                                                ¦
                                 ¦C                                                ¦
1. (cont)                        ¦---------------------------------------------^¦
                                 ¦              (12 mm)                            ¦
2. (cont)                        ¦-----------------------------------------------¦
                                 ¦              (12 mm)                            ¦
                                 ¦                               Report No. 2¦
3. (cont)                        ¦---------------------------------------------^¦
                                 ¦              (12 mm)                            ¦
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REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER: 306M03

TITLE: IVA/EVA TASKS AND LEARNING CURVES

DATE: 07-16-85

	1987			1988								
CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S
FISCAL	FY 88											
MONTH	1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												
STUDY TASKS												Report No. 3
	A											
	B											
	C											
1. (cont)	(12 mm)											
2. (cont)	(12 mm)											Report No. 3
3. (cont)	(12 mm)											

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
306M03	IVA/EVA TASKS AND LEARNING CURVES	07-16-85

```
                                        1988         |    1989                              |
                               CALENDAR|O--N--D--|J--F--M--A--M--J--J--A--S|
                                 FISCAL|FY 89                                               |
                                  MONTH|1   2   3    4   5   6   7   8   9  10  11  12|
                                PHASE B|                                                    |
                                      C|                                                    |
STUDY  TASKS                           |                                  Report No. 4|
                                       |A                                                   |
                                       |B                                                   |
                                       |C                                                   |
1. (cont)                              |-------------------------------------------^|
                                       |            (12 mm)                                 |
2. (cont)                              |--------------------------------------------|
                                       |            (12 mm)                                 |
                                       |                                  Report No. 4|
3. (cont)                              |-------------------------------------------^|
                                       |            (12 mm)                                 |
                                       |                                                    |
```

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
306M03	IVA/EVA TASKS AND LEARNING CURVES	07-16-85

SUMMARY SCHEDULE/COST FACTORS

STUDY SPAN OCT 84-SEP 89 CM = 48

CATEGORY	FACTOR/MM(CM)*	COST $
LABOR		
- NASA Project Mgmt	12 mm	
- Study Mgmt	12 mm	
- Study Tasks		
- Analyst, Eng'g	131 mm	
- Special Skills:		
-Astronauts (2)	10 mm	
Skills Cost		
SPECIAL FACILITIES		
Videotape Viewing Lab		
TRAVEL		
None		
MATERIALS		
Videotape Machine & Monitor		
Computer terminal		
TEST PROGRAM		
STS Flight Experiments	10hrs/year(est)	
OTHER (List)		
None		

* MM = Manmonths; CM = Calendar Months

REPORT FORMAT 13 MANAGEMENT PLAN OVERVIEW

NUMBER	TITLE	DATE
306M04	GROUND SUPPORT FOR LONG RANGE PLANNING	6-28-85

ISSUE #	TITLE	NEED DATE
3060304	GROUND SUPPORT FOR LONG RANGE PLANNING	AUG 86

OBJECTIVES:

(01) Define long-range scheduling parameters.

(02) Define ground responsibilities for long-range scheduling parameters.

BACKGROUND:

Global planning includes establishment of preliminary general time allocations for work, rest, recreation, and leisure time activities. This Global planning also includes definition of payload scheduling taking into account such things as crew size, crew skills, orbital location, utility (power, data, thermal) resource allocation, resupply, vehicle traffic, level of automation, automated on-board scheduling systems, etc. It will then be up to the crew to autonomously create a more precise, short range schedule of events with individually-tailored sleep, exercise, meals, work, experiments, etc. scheduling objectives.

The purpose of this study is to establish the nature of the ground support required to establish long range scheduling. This long range Global planning will enable the flight crew to do autonomous daily and weekly planning.

INPUTS:

A. LESSONS LEARNED RECORDS OF PAST MANNED SPACEFLIGHT MISSIONS
B. SPACE STATION MISSION OBJECTIVES
C. RESOURCE MANAGEMENT PLANS AND CONSTRAINTS
D. LENGTH OF MISSION(S)
E. CREW ACTIVITY SCHEDULING RESULTS FROM MANAGEMENT PLAN 306M01
F. EXPERT SCHEDULING SYSTEM REQUIREMENTS FROM MANAGEMENT PLAN 306M02
G. ORGANIZATIONAL STRUCTURE REQUIREMENTS FROM MANAGEMENT PLAN 308M01

CRITICAL ASSUMPTIONS:

(01) The crew will be able to plan their near-term schedules and adjust schedules to meet unexpected situations.

(02) Weekly plans can be scheduled based on NASA "global" plans for the mission(s).

(03) Daily plans can be rescheduled in response to "global" plans.

(04) Ground support scheduling responsibilities can be harmoniously integrated with the near-term scheduling to be done by the flight crew.

SPECIAL REMARKS:

(01) This study will interact with the Management Plan 308M01, Organizational Structure, 306M01, Crew Activity Scheduling, and 306M01 306M02, Expert Scheduling System Requirements. July 87

(02) The on-orbit resource availability (i.e., power, heat rejection, communication channels, etc.) will be a limiting factor in scheduling.

(03) The on-orbit crew workload is the most important factor in scheduling.

(04) Reference 1 provides some valuable insights relative to global planning that have been obtained from NASA, Soviet, and nuclear submarine experience.

REFERENCES:

(01) "Space Station Habitability Design Recommendations, Vols. II", D180-28401-1, Boeing Aerospace Co., 11/15/84

REPORT FORMAT 14 STUDY PLAN

NUMBER	TITLE	DATE
306M04	GROUND SUPPORT FOR LONG RANGE PLANNING	6-28-85

STUDY TASKS:

(01) Define Global Scheduling Parameters -
a. Review STS mission operations planning data to identify scheduling parameters.
b. Review SS payload descriptions and mission model to define payload scheduling parameters.
c. Obtain SS utility systems (power, thermal, data, etc.) resource scheduling parameters.
d. Obtain crew scheduling parameters (from Management Plan 306M01).
e. Obtain resupply mission scheduling parameters .
f. Obtain maintenance operations scheduling parameters
g. Obtain orbital station-keeping scheduling parameters
h. Determine availability and level of capability of the on-board scheduling systems from Management Plan 308M01 - Expert Scheduling System Requirements.

(02) Allocate Parameter Scheduling Responsibility - Using the parameter data from Task 01, define which parameters should/can be scheduled by ground support vs those to be scheduled on-board station. Take into account the expert scheduling system concept being defined by Management Plan 306M02. The organizational structure being defined by Management Plan 306M02 must also be taken into account.

SPECIAL STUDY NEEDS:

TASK(S)	NEED
	None

SPECIAL SKILLS:

TASK(S)	SKILL
1,2	Mission Operations Planner
1,2	Crew Systems Analyst

PERFORMING ORGANIZATION:

(01) Managing: NASA Level B

(02) Doing: Aerospace Prime Contractor

STUDY PRODUCTS:

(01) Definition of global schedule planning parameters.

(02) Definition of ground vs. on-orbit responsibility for control of specific scheduling parameters.

PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS:

SUBELEMENT NO. & TITLE	Undefined Rqmt #
30603 Scheduling Methods	-01, -02, -26

REPORT FORMAT 15   SCHEDULE-TASK FLOW

```
NUMBER                          TITLE                                  DATE
306M04      GROUND SUPPORT FOR LONG RANGE PLANNING                     6-28-85

                                         1985      |    1986                    |
                                CALENDAR|O--N--D--|J--F--M--A--M--J--J--A--S|
                                  FISCAL|FY 86                                  |
                                   MONTH|1  2  3   4  5  6  7  8  9 10 11 12|
                                 PHASE B|                                       |
                                       C|                                       |
STUDY  TASKS                            |                                       |
                                        |          A                            |
                                        |          B                            |
                                        |          C                            |
                                        |          D                            |
                                        |          E                            |
1. Define Global Planning Parameters    |          ------------                 |
                                        |             (6 m/m)                   |
                                        |                     F                 |
                                        |                     G                 |
2. Allocate Parameter Scheduling        |                      ---------        |
Responsibility                          |                       (3 m/m)         |
                                        |                                       |
                                        |                                       |
                                        |                                       |
                                        |                                       |
                                        |                                       |
                                        |                                       |
                                        |                                       |
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REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
306M04	GROUND SUPPORT FOR LONG RANGE PLANNING	6-28-85

SUMMARY SCHEDULE/COST FACTORS

STUDY SPAN: JAN 86-JUL 86 CM = 6

CATEGORY	FACTOR/MM(CM)*	COST $
LABOR		
- NASA Project Mgmt		
- Study Mgmt	6 mm	
- Study Tasks		
- Analyst, Eng'g	9 mm	
- Special Skills:		
SPECIAL FACILITIES		
TRAVEL		
MATERIALS		
TEST PROGRAM		
OTHER (List)		

* MM = Manmonths; CM = Calendar Months

REPORT FORMAT 13 MANAGEMENT PLAN OVERVIEW

NUMBER	TITLE	DATE
306M05	IMPORTANT/ESSENTIAL SKILLS FOR JOB ROTATION	6-28-85

ISSUE #	TITLE	NEED DATE
3060201	IMPORTANT/ESSENTIAL SKILLS FOR JOB ROTATION	NOV 86

OBJECTIVES:

(01) Determine essential skills that all crew members must have.

(02) Determine non-essential, but important or desireable skills that all crewmembers should have.

BACKGROUND:

Previous flight crews have been composed primarily of career astronauts. Extensive training for missions has been spacecraft and payload operations-oriented. By contrast, Space Station crews will contain both career astronauts, who will operate the Station, and non-career astronaut personnel whose primary missions will be scientific and/or industrial in nature. In view of this mixture of crewmembers, a determination must be made as to what tasks aboard the Space Station all crewmembers must be able to perform. In addition, skills which are important, but not essential for the entire crew to have must also be identified. This issue resolution study will result in the definition of these requirements.

INPUTS:

A. PROJECTED SPACE STATION OPERATIONS TASKS
B. NASA CREW TRAINING DATA
C. PROPOSED CREW PROFILE DATA
D. PREVIOUS SPACEFLIGHT MISSION DATA
E. DATA FROM MISSIONS INVOLVING LONG-TERM STAYS IN ISOLATION
F. CREW TRAINING/SKILL PROFILES FROM MISSIONS IN LONG-TERM ISOLATION

CRITICAL ASSUMPTIONS:

(01) SDR 17 Nov - 1 Dec 1986

SPECIAL REMARKS:

(01) This study will consider basic crew skill requirements for safety on-board the station

(02) This study will consider Space Station system operations-specific skills

(03) This study will consider mission-specific skills

REFERENCES:

(01) None

REPORT FORMAT 14 STUDY PLAN

NUMBER	TITLE	DATE
306M05	IMPORTANT/ESSENTIAL SKILLS FOR JOB ROTATION	6-23-85

STUDY TASKS:

(01) Define Essential Skills - Determine essential skills which all crewmembers must possess

(02) Define Important Skills - Determine non-essential, but important skills which all crewmembers should possess

SPECIAL STUDY NEEDS:

TASK(S)	NEED
	None

SPECIAL SKILLS:

TASK(S)	SKILL
1,2	Crew Systems analyst familiar with basic skills required for space missions, projected Space Station operations, and with job rotation performed in previous earth- and space-based missions involving long-term isolation.

PERFORMING ORGANIZATION:

(01) Managing: NASA - JSC, Crew Training

(02) Doing: Aerospace Contractor

STUDY PRODUCTS:

Specifications document which defines:

(01) Essential skills all crewmembers must have

(02) Important skills all crewmembers should have

PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS:

SUBELEMENT NO. & TITLE	Undefined Rqmt #
30602 Job Rotation	-07, -08

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
306M05	IMPORTANT/ESSENTIAL SKILLS FOR JOB ROTATION	6-28-85

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                                          1985        :     1986                          :
                                  CALENDAR:O--N--D--:J--F--M--A--M--J--J--A--S:
                                    FISCAL:FY 86                                           :
                                     MONTH:1  2  3   4  5  6  7  8  9 10 11 12:
                                 PHASE B:                                                  :
                                        C:                                                 :
STUDY  TASKS                             :                                                 :
                                         :               A                                 :
                                         :               B                                 :
                                         :               C                                 :
Assumes SDR Nov 86                       :               D                                 :
                                         :               E                                 :
                                         :               F                                 :
1. Define Essential Skills               :               -------                           :
                                         :                (2m/m)                           :
2. Define Important Skills               :               -------                           :
                                         :                (2m/m)                           :
```

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
306M05	IMPORTANT/ESSENTIAL SKILLS FOR JOB ROTATION	6-23-85

SUMMARY SCHEDULE/COST FACTORS

STUDY SPAN: MAR 86-APR 86 CM = 2

CATEGORY	FACTOR/MM(CM)*	COST $
LABOR	0.5 mm	
- NASA Project Mgmt		
- Study Mgmt	2.0 mm	
- Study Tasks		
- Analyst, Eng'g	4.0 mm	
- Special Skills:		

SPECIAL FACILITIES

TRAVEL

MATERIALS

TEST PROGRAM

OTHER (List)

* MM = Manmonths; CM = Calendar Months

REPORT FORMAT 13 MANAGEMENT PLAN OVERVIEW

NUMBER	TITLE	DATE
306M06	SPACE STATION PRODUCTIVITY MEASUREMENT	6-23-85

ISSUE #	TITLE	NEED DATE
3060107	PRODUCTIVITY FACTORS	OCT 90

OBJECTIVES:

(01) To define the methods and parameters to be used to measure Space Station human productivity.

BACKGROUND:

The Space Station Human Productivity Study (Ref. 1) was created to define the requirements which need to be met by the system design and operations in order to maximize on-orbit crew productivity. The Human Productivity Study has generated requirements (Ref. 2) and issue resolution management plans such as this one.

This Management Plan is directed at defining the specific parameter(s) which will be used to measure the Space Station on-orbit crew productivity.

There are a number of types of productivity measures which have been used in industrial/research settings. These include technical measures (e.g., ratio of pounds input to pounds output), economic measures (e.g., dollars per pound of output product), schedule measures (e.g., number of units per year), success measures (e.g., actual vs forecast output), and social measures (e.g., worker s perceived job satisfaction).

In this study it will be necessary to resolve many basic issues (Ref. 3):

o Must a single measure be used or should a combination of measures be developed?

o Is the purpose to measure human productivity level, trend, or percent of standard?

o Is the output measure the true output or is a surrogate measure required? (e.g., true output = pounds of end product; surrogate measure = Consumer Price Index)

o Can the data needed for the measure be routinely reported?

o How frequently should results be reported? Etc.

This study will thoroughly examine these and other issues. The result will be a Space Station-tailored productivity measurement technique which includes both technical and management factors.

INPUTS:

A. SPACE STATION MISSIONS
B. SPACE STATION HOUSEKEEPING FUNCTIONS
C. SPACE STATION CREW SCHEDULES

CRITICAL ASSUMPTIONS:

(01) None

SPECIAL REMARKS:

(01) The study approach is adapted from Ref. 4.

REFERENCES:

(01) Solicitation No. 9BE3-6-4-27P "Space Station Human Productivity Study", NASA-JSC, July 23, 1984

(02) "Space Station Human Productivity Requirements", NASA-JSC (Doc. No. TBD), (release date TBD).

(03) Thor, Carl, "How Well Does Your Measure Measure Up?", Productivity Brief 5, American Productivity Center, Sept. 1981

(04) Dunnette, M.D. and Fleishman, E.A., "Chapter 2, Evaluating Productivity: Guidelines for a Productivity Assessment System), Human Performance and Productivity, Lawrence Erlbaum Assoc. Publishers, 1982

REPORT FORMAT 14 STUDY PLAN

NUMBER	TITLE	DATE
306M06	SPACE STATION PRODUCTIVITY MEASUREMENT	6-23-85

STUDY TASKS:

(01) Information Needs Analysis - Define the uses for the productivity measurement system. Answer these questions: 1) What do you want to know?, and 2) What are you going to do with the information once you have it?

(02) Performance Objectives Analysis - Define what performance or study behaviors are valued by the crew, the relative importance of these behaviors, and the requirements for each behavior.

(03) Performance Indices Analysis - Manipulations of the basic measurement data will occur in the form of productivity indices. Determine what kinds of indices will be used.

(04) Specification of Measurement Dimensions - Integrate the results of Tasks 1, 2, and 3 to define "what" will be measured.

(05) Comparison of Alternative Measure Sets - For the measurement dimensions selected in Task 4, define the alternative measures which can be used to express the dimension. This step defines the "how" of measurement. Evaluate the alternatives against criteria such as validity, reliability, precision, non-creativity, generalizability, utility, and acceptability.

(06) Preliminary Test of Alternative Measures - Conduct a preliminary test of the alternative measures. Consider using NASA simulators or STS flights as test facilities.

(07) Instrumentation and Processing - Define the instrumentation and data processing required to collect, process and document the productivity measurement data.

(08) Resource Analysis - Evaluate the resources that are required to produce the measurement system.

(09) Quality Control - Define the quality control process to be used to provide for periodic checks of the data base to ensure that good data are being put into the system.

(10) Selection of Final Measure Set - Reiterate the previous tasks as required to result in an acceptable productivity measurement system.

(11) Installation and Operation of Final Measure Set - Make the system operational. Instigate the on-going process to collect, analyze, and document the data.

SPECIAL STUDY NEEDS:

TASK(S)	NEED

6	Crew training simulator or STS

SPECIAL SKILLS:

TASK(S)	SKILL
1,2,6	Astronauts
1,2,3,4,5,6,7, 8,9,10,11	Industrial Engineer
1,2,6	Behavioral Psychologist
1,2	Space Station Program Managers, Level A, B, C

PERFORMING ORGANIZATION:

(01) Managing: NASA - Level B (Prime)
NASA - Ames Research Center, Space Human Factors Div. (Study Monitor)

(02) Doing: Industrial Engineering Contractor (Prime)
Productivity Consultants (Sub)

STUDY PRODUCTS:

(01) Specification of Space Station on-orbit crew productivity measure

(02) Definition of technical and management process to be used to collect, analyze, and disseminate productivity measurement data.

PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS:

SUBELEMENT NO. & TITLE	Undefined Rqmt #
30601 Activity Planning/Scheduling	-29

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
306M06	SPACE STATION PRODUCTIVITY MEASUREMENT	6-23-85

	1987			1988								
CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S
FISCAL	FY 88											
MONTH	1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												
STUDY TASKS												
Assumes CDR 18 April 1990							A					
							B					
							C					
1. Information Needs Analysis							------					
							(2m/m)					
2. Performance Objectives Analysis							-------					
							(2m/m)					
3. Performance Indices Analysis							-------					
							(2m/m)					
4. Specification of Measurement									---			
Dimensions									(2m/m)			
5. Comparison of Alternative Measure										-------		
Sets										(4m/m)		

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
306M06	SPACE STATION PRODUCTIVITY MEASUREMENT	6-23-85

	1988			1989								
CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S
FISCAL	FY 89											
MONTH	1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												

STUDY TASKS	Schedule
Assumes CDR 18 April 1990	
1.	
2.	
3.	
4.	
5.	
6. Preliminary Test of Alternative Measures	months 1–6 (12m/m)
7. Instrumentation and Processing	months 7–9 (3m/m)
8. Resource Analysis	months 7–9 (3m/m)
9. Quality Control	months 7–9 (1m/m)
10. Select Measurement System	months 10–11 (3m/m)
11. Install & Operate Measurement System	(@ IOC in 1992) (6m/m)

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
306M06	SPACE STATION PRODUCTIVITY MEASUREMENT	6-23-85

SUMMARY SCHEDULE/COST FACTORS

STUDY SPAN: APR 88-OCT 89 CM = 18

CATEGORY	FACTOR/MM(CM)*	COST $
LABOR		
- NASA Project Mgmt	18 mm	
- Study Mgmt	18 mm	
- Study Tasks		
- Analyst, Eng'g		
- Special Skills:		
- Astronaut	6 mm	
- Industrial Engr.	26 mm	
- Behavioral Psychologist	6 mm	
- SS Mgrs. (Land A, B, C)	2 mm	
SPECIAL FACILITIES		
TRAVEL		
- Contractors travel to JSC, ARC		5 K
- Covt. travel JSC/ARC		5 K
MATERIALS		
TEST PROGRAM		
- Simulator or flight test		(TBD)
OTHER (List)		

* MM = Manmonths; CM = Calendar Months

REPORT FORMAT 13 MANAGEMENT PLAN OVERVIEW

NUMBER	TITLE	DATE
308M01	ORGANIZATIONAL STRUCTURE	07-16-85

ISSUE #	TITLE	NEED DATE
3080101	ORGANIZATIONAL STRUCTURE	NOV 89

OBJECTIVES:

(01) To define an organizational structure which allows the flight crew to control their own schedule based on the goals which NASA has set.

(02) To define the interfaces of the organizational structure between flight and ground crews.

(03) To determine who will be responsible for making decisions involving the entire crew and/or certain areas of specialization in both normal and off-normal modes of operation.

(04) To define provisions for the emergence of informal organizational structures which will be supportive of the formal structure.

(05) To define the organizational system that facilitates open and clear communication between the ground and flight crews.

BACKGROUND:

The Space Station will provide a working situation that will present NASA with some interesting choices when it comes to setting up a ground and flight crew organizational structure:

a. There will be a relatively large crew size on orbit (start with 6 and grow to 15 - 20).

b. Early in the program, there will be a relatively large ground crew. This ground crew will be paired down as tasks are shifted to the flight crew.

c. There will be customer astronauts on-board.

There are mixed opinions from crews who have worked in the Antarctic (Ref. 01) as to whether an authoritarian or a less-structured organizational system is preferreed. The astronauts who were interviewed (Ref. 02) also are split on whether a military-type command structure, a knowledge-based authority, or a crisis management system would be preferred. Nuclear submarine crews are organized in typical military authority structures, but while at sea, the structure becomes less formal (Ref. 03).

This study will analyze alternative organizational concepts to devise a workable organizational structure for the flight and ground crews.

INPUTS:

A. Documented records of organizational systems used in Analog Isolated Habitation missions.
B. NASA requirements on communication and organizational structure.
C. Areas of task specialization
D. Ground and flight crew skills
E. Results of Management Plan 308M02 - AIR TO GROUND PROBLEM RESOLUTION.
F. Results of Management Plan 309M01 - AUTONOMY TECHNOLOGY/ TIME-PHASING
G. Results of Management Plan 309M02 - ON-ORBIT VS. GROUND OFF-NOMINAL ACTIVITIES PROTOCOL
H. Results of Management Plan 309M03 - ON-ORBIT VS. GROUND CREW TASK ASSIGNMENT

CRITICAL ASSUMPTIONS:

(01) The need for constant communication between flight crew and ground control will be diminished as on-board autonomy increases.

(02) Assumes CDR in April 1990.

SPECIAL REMARKS:

(01) Care must be taken in applying the results obtained from the various analog settings to the peculiar nature of the Space Station's personnel, environment, and assigned tasks.

(02) Results of other studies show that future missions of isolated habitability crews can be very productive in an autonomous structure if the crew members are responsible enough to work independently.

(03) It may be advantageous to conduct the missions with the flight crew having open, but limited, lines of communication with the ground. This would make the crew basically self-reliant during the mission.

REFERENCES:

(01) Space Station/Antarctic Analogs, NASA Grants NAG2-255/NAGW-659, (unreleased document), 1985

(02) Space Station Habitability Design Recommendations, Vol. I and II, D180-28401-1 and -2, Boeing Aerospace Co., 15 Nov 1984

(03) Space Station/Nuclear Submarine Analogs, D180-28181-1, Boeing Aerospace Company, Oct 1983

REPORT FORMAT 14 STUDY PLAN

NUMBER	TITLE	DATE
308M01	ORGANIZATIONAL STRUCTURE	07-16-85

STUDY TASKS:

(01) Conduct Literature Search - Conduct a literature search for analog situations beyond those already researched in Ref's. 1, 2, and 3. Assess the organizational structures used and the lessons learned.

(02) Evaluate Application to Space Station - Evaluate the various organizational concepts defined in Task 01 in view of the Space Station work situation. Take into account the evolving autonomy of the flight crew. Define the organizational interfaces between the ground and flight crews. Consider normal and non-normal modes of operation. Take into account the presence of customer astronauts and foreigners. Determine provisions for the emergence of informal organizational structures.

Have astronauts, NASA management, and mission control, specialists evaluate the alternative organizational concepts.

(03) Define Organization Structure - Define the organizational structures for the flight and ground crews.

SPECIAL STUDY NEEDS:

TASK(S)	NEED
1	Previous studies done on isolated crew habitats
2	Results of other Management Plans:
	308M02 AIR-TO-GROUND PROBLEM RESOLUTION
	309M01 AUTONOMY TECHNOLOGY/TIME-PHASING
	309M02 ON-ORBIT VS. GROUND OFF-NOMINAL
	309M03 ON-ORBIT VS. GROUND TASK ASSIGNMENT

SPECIAL SKILLS:

TASK(S)	SKILL
1,2	Management Consultant
1,2	Behavioral Psychologist
2	NASA Manned Spaceflight Mission Managers
2	Astronauts

PERFORMING ORGANIZATION:

(01) Managing: NASA - JSC, Level B

(02) Doing: Management Consultant Firms (Prime)
Behavioral Science Consultant (Sub)

STUDY PRODUCTS:

Definition of the ground and flight crew organizational structures.

PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS:

SUBELEMENT NO. & TITLE	Undefined Rqmt #
30801 ORGANIZATIONAL STRUCTURE	-18,-21,-23,-24

REPORT FORMAT 15   SCHEDULE-TASK FLOW

NUMBER   TITLE   DATE
308M01   ORGANIZATIONAL STRUCTURE   07-16-85

```
                                       1987       |   1988                                |
                               CALENDAR|O--N--D--|J--F--M--A--M--J--J--A--S|
                                 FISCAL|FY 88                                    |
                                  MONTH|1  2  3   4  5  6  7  8  9 10 11 12|
                                PHASE B|                                         |
                                      C|                                         |
STUDY  TASKS                           |                                         |
Assumes CDR April 1990                 |               A                         |
1. Conduct Literature Search           |               -------                   |
                                       |               (2 mm)                    |
                                       |                    B                    |
                                       |                    C                    |
                                       |                    D                    |
                                       |                    E                    |
                                       |                    F                    |
                                       |                    G                    |
                                       |                    H                    |
2. Evaluate Application to Space       |                     -------             |
   Station                             |                      (6.5 mm)           |
                                       |                                         |
3. Define Organizational Structure     |                             -------|
                                       |                             (2 mm)|
                                       |                                         |
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REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
308M01	ORGANIZATIONAL STRUCTURE	07-16-85

SUMMARY SCHEDULE/COST FACTORS

STUDY SPAN: MAR 88-OCT 88 CM = 6

CATEGORY	FACTOR/MM(CM)*	COST $
LABOR		
- NASA Project Mgmt	3 mm	
- Study Mgmt	6 mm	
- Study Tasks		
- Analyst, Eng'g		
- Special Skills:		
- Management Consultant	6 mm	
- Behavioral Psychologist	4 mm	
- NASA Mannes System Program Mgr.	1 wk	
- Astronauts	1 wk	
SPECIAL FACILITIES		
TRAVEL		
- To JSC		2 K
MATERIALS		
TEST PROGRAM		
OTHER (List)		

* MM = Manmonths; CM = Calendar Months

REPORT FORMAT 13 MANAGEMENT PLAN OVERVIEW

NUMBER	TITLE	DATE
308M02	METHODS TO ENHANCE COMPATIBILITY	07-17-85

ISSUE #	TITLE	NEED DATE
3080204	AIR-TO-GROUND PROBLEM RESOLUTION	OCT 89

OBJECTIVES:

(01) Develop a system to provide support for resolution of conflicts between the flight and ground crews.

BACKGROUND:

There will inevitably be internal and external conflicts in any management situation. Therefore, it is essential to have a system which will allow the members within that management structure to resolve the conflicts that will ensue. It will be necessary to have an organizational structure and conflict management skills so that open communication between the Space Station flight crew and ground control are facilitated.

Space Station Habitability Design Recommendations (Ref. 1) discusses the importance of having open communication within the authority structure as well as between air and ground crews. Both US and Soviet crews have had episodes where the flight crews and the ground support crews have had serious conflicts which led the frustrated flight crews to temporarily discontinue communications with the ground.

This issue resolution study will investigate the factors involved in prior air vs ground crew conflicts and will devise a plan for dealing with future situations in a more productive manner.

INPUTS:

A. Documented records of conflicts experienced on past isolated habitation missions (e.g., References 1 and 2)
B. NASA requirements for communications on space missions.
C. An authority structure which should be followin in Off-Nominal Situations (Management Plan 309M02)

CRITICAL ASSUMPTIONS:

(01) Conflicts will arise between the air-to-ground crews.

(02) Assumes CDR to begin in April 1990.

SPECIAL REMARKS:

(01) None

REFERENCES:

(01) "Space Station Habitability Design Recommendations, Vol. I and II, Boeing Aerospace Co., D180-28402-1, 15 Nov 1984

REPORT FORMAT 14 STUDY PLAN

NUMBER	TITLE	DATE
308M02	METHODS TO ENHANCE COMPATIBILITY	07-17-85

STUDY TASKS:

(01) Literature Survey - Review documentation of previous US and Soviet flight vs ground crew conflicts which have led to the point where the flight crew has temporarily disconnected or stopped air-to-ground communication. Document the factors that led to these disputes.

(02) Define Conflict Resolution Alternatives - Define several alternative conflict resolution approaches. These include training, organizational, and negotiating techniques.

(03) Evaluate Alternative Approaches - Convene a workshop composed of NASA mission operations management, ground operators, astronauts (current STS crews as well as Skylab astronauts), behavioral psychologists, and others. Present the alternatives and have this working group evaluate them..

(04) Select and Document Approach - Select the preferred approaches and document the rationale for their selection.

SPECIAL STUDY NEEDS:

TASK(S)	NEED
1	Previous studies done on STS missions and other isolated habitats.
2	An outline for a functional organizational support structure.

SPECIAL SKILLS:

TASK(S)	SKILL
3	Astronauts (STS and Skylab)
3	Behavioral Psychologists
3	Mission Control Manager
3	Mission Control Ground Operator

PERFORMING ORGANIZATION:

(01) Managing: NASA - Ames Research Center, Space Human Factors Branch

(02) Doing: Behaviorial Science Consulting Firm

STUDY PRODUCTS:

Specification of the management, training, and negotiating processes to be used to resolve ground vs flight crew conflicts before these conflicts impact the mission.

<u>PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS</u>:

SUBELEMENT NO. & TITLE	Undefined Rqmt #
30802 METHODS TO ENHANCE COMPATIBILITY	-01

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
308M02	METHODS TO ENHANCE COMPATIBILITY	07-17-85

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                                  1988          |   1989                                  |
                         CALENDAR|O--N--D--|J--F--M--A--M--J--J--A--S--|
                           FISCAL|FY 89                                 |
                            MONTH|1  2  3   4  5  6  7  8  9  10 11 12  |
                          PHASE B|                                      |
                                C|                                      |
STUDY  TASKS                     |                                      |
Assumes CDR April 1990           |                    A                 |
                                 |                    B                 |
                                 |                    C                 |
1. Literature Survey             |                      ---             |
                                 |                     (1 mm)           |
2. Define Conflict Resolution    |                         ---------    |
   Approaches                    |                          (3 mm)      |
                                 |                                      |
3. Evaluate Approaches           |                                  --  |
                                 |                              (5 mm)  |
4. Select and Document Approach  |                                  --- |
                                 |                              (1 mm)  |
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REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
308M02	METHODS TO ENHANCE COMPATIBILITY	07-17-85

SUMMARY SCHEDULE/COST FACTORS

STUDY SPAN:	MAY 89-OCT 89	CM = 5
CATEGORY	FACTOR/MM(CM)*	COST $
LABOR		
- NASA Project Mgmt	0.5 mm	
- Study Mgmt	0.5 mm	
- Study Tasks		
- Analyst, Eng'g	6 mm	
- Special Skills:		
- Astronauts (min. of 2)	.5 mm (ea)	
- Mission Conrtol Mgr.(Min of 2)	.5 mm (ea)	
- Mission Cont.Grnd Cntrlr(min of 2)	.5 mm (ea)	
- Behavioral Psychologist	1 mm	
SPECIAL FACILITIES		
TRAVEL		
- Study Leader travel to JSC		2 K
MATERIALS		
TEST PROGRAM		
OTHER (List)		

* MM = Manmonths; CM = Calendar Months

REPORT FORMAT 13 MANAGEMENT PLAN OVERVIEW

NUMBER	TITLE	DATE
309M01	AUTONOMY TECH SELECTION/TIME PHASING	07-16-85

ISSUE #	TITLE	NEED DATE
3090101	AUTONOMY TECH SELECTION/TIME PHASING	JUL 86

OBJECTIVES:

(01) Select the technologies necessary to implement autonomy on the Space Station.

(02) Define time-phasing of autonomy implementation, to include the degree of autonomy to be achieved for the initial and growth Space Station.

BACKGROUND:

Autonomy will be defined herein as routine operation of the SSP, independent of intervention by ground support or on-orbit personnel. Autonomy will be implemented through the use of automation and robotics on the Space Station. The purpose of using this automation and robotics is to liberate the crew to be used in their most productive capacities as decision makers and observers in the operation of payloads.

Congress has recognized the benefits of automation and robotics and mandated that they be integrated into the SSP to a significantly greater degree than for previous manned space systems. Thus, the Space Station has been given the role of being a driver of autonomy technologies.

During the past few years, several automation and robotics working groups have been formed to address this subject. Considerations of autonomy have also been addressed at some length in various studies (e.g., Refs. 1 and 2). These groups and studies have made strong beginnings in defining the critical technologies necessary to achieve automation, but none have advanced a definite set of requirements and specific timetable for SSP implementation.

There are two major roadblocks in constructing such a hard requirements document. The first is that some critical automation technologies are immature. The second is that hard budgetary decisions are necessary, but the data with which to make those decisions are not available. With the Phase B SDR now only months away, and PDR and CDR following in the succeeding years, these data must be developed quickly and the critical technologies needing advancement prior to the initial station design freeze must be identified.

This management plan outlines a study to perform those tasks. It proposes an effort to identify the requisite technologies, perform the cost trades leading to initial/growth autonomy phasing

recommendations, identify the technologies needing advancement for the initial station, and indicate the scarring necessary to accommodate growth autonomy.

INPUTS:

A. Data from automation and robotics working groups
B. Output from SSP Data Management System Study
C. Advanced Technology Advisory Committee Recommendations Document
D. All relevant Autonomy/Automation/Robotics papers
E. SSP DDT&E and Life-Cycle cost models including baseline data
F. Data from Phase B tasks 3.2.2.8 Automation and Robitics and 3.2.2.9 Evolutionary Growth (Ref.3)
G. Phase B Contractors' relevant IR&D and output timelines (from "Related Activities" reports)
H. SSP current baseline design
I. Results from ON-ORBIT VS. GROUND TASK ASSIGNMENT (Management Plan 309M03)

CRITICAL ASSUMPTIONS:

(01) SDR in Dec. 86

(02) The analysis to be performed in Management Plan 309M03 will be time-phased with this Study.

SPECIAL REMARKS:

(01) The purpose of autonomy is not to replace the crew. The purpose is to automate as much of the routine utilities management and payload operations as feasible so that the crew can be liberated to be utilized in their most productive capacities as observers, decision makers, etc.

(02) The March 1986 need date represents an estimate of the minimum possible lead time in which significant design specification changes can still be inserted into the Phase B SDR cycle. However, because of the magnitude of this study, a strongly-manned effort is necessary to achieve a truly useful product in the compressed timeframe. The final report may be published after the need date, but all other study products must be delivered before the end of March 1986.

(03) This effort requires a group of dedicated people working full-time to achieve the study objectives to produce the outputs. The tasks could be performed by (1) NASA, (2) an aerospace firm, or (3) a mixed group under NASA leadership. The important requirements are that the skill mix be appropriate, and that the group work cohesively from the onset.

(04) Timelines assume task planning has already taken place before start.

REFERENCES:

(01) "Autonomous Spacecraft Design and Validation Methodology Handbook", SD-TR-82-58, USAF Systems Command Headquarters, Space Division, Los Angeles, CA 90009, 30 Apr 1982

(02) "Implementing Space Station Autonomy/Automation," (Volkner, Staehle and Zimmerman) Jet Propulsion Laboratory, California Institute of Technology, 14 Aug 1984

(03) NASA Solicitation #9-BF-10-4-01P, "Space Station Definition & Preliminary Design, Request for Proposal", Sep 1984

REPORT FORMAT 14 STUDY PLAN

NUMBER	TITLE	DATE
309M01	AUTONOMY TECH SELECTION/TIME PHASING	07-16-85

STUDY TASKS:

(01) Identify Autonomy Technologies - Conduct a technology literature search and contact topical experts. This search should be inclusive of all aspects of current and anticipated growth SSP design. It should include free-flying platforms, OMV/OTV, and the man-tended option.

(02) Assess Technology Status - For all technologies identified in Task #1, determine maturity, current advancement plan, and additional work required to achieve SSP DDT&E readiness. Include estimates of time to completion and probability of success by development.

(03) Determine Initial Station Options - Determine achievable automation and robotics options for the initial stations. This selection might include relatively immature technology which could be brought to DDT&E readiness by a large front-end development effort begun immediately.

(04) Perform Parametric Analyses - Perform parametric cost analyses for all IOC-achievable automation and robotics. Factors to consider include additional R&D expenditures necessary, increased DDT&E costs relative to currently-planned baseline, savings in DDT&E through not having to scar for growth, savings in operating and life-cycle costs (Including training), savings in on-orbit personnel-hours, etc. Intangibles such as crew comfort and safety should also be documented. Note that any one technology might be interactive with others, with respect to development and/or life-cycle costing.

(05) Prioritize Achievable Autonomy - Develop a weighted scoring (or other) system which takes into account all of the factors listed in Task #4, and other factors which might be relevant (such as ATAC recommendatins and program risk). Use this to rank the SSP automation and robotics options available, documenting the prioritization with cost/benefit data. In consultation with NASA management, develop firm recommendations for IOC and growth station autonomy. This entire process should be accomplished for both the manned and man-tended options if the final choice between these has not yet been made.

(06) Develop Action Plans and Funding Recommendations - Develop action plans and funding recommendations for immediate additional advancement of technologies as necessary to achieve the initial station autonomy. Forward plans immediately to NASA for action.

(07) Develop Growth Timelines and Scarring Recommendations - Develop timelines for insertion of additional automation into the growth station. Take into account the most likely growth scenarios, as derived from Phase B contractors' outputs from Tasks 3.2.2.8 and 3.2.2.9, and in consultation with NASA. Identify scarring

necessary for the IOC configuration to minimize the impact of growth autonomy insertion. Recommended scarring data should be forwarded for immediate dissemination by NASA to the Phase B contractors.

(08) Prepare final report.

SPECIAL STUDY NEEDS:

TASK(S)	NEED
4	Computer with capability to run the cost-estimating models (see Inputs). This computer should be reserved for dedicated use during the prformance of Study Task #4

SPECIAL SKILLS:

TASK(S)	SKILL
4	At least one person familiar with the cost-estimating models to be used, and able to run them interactively on a computer.
1,2,3,4,5,6,7,8	See second item in "Special Remarks". The study group should have collective familiarity with control aspects of all SSP technology disciplines (Power, ECLS, thermal, propulsion, EVA and manned systems, etc), with extra emphasis on autonomy data management and systems integration. Strong, goal-oriented leadership is essential.

PERFORMING ORGANIZATION:

(01) Managing: NASA/JSC, Level B
NASA/ARC

(02) Doing: Aerospace Firms

STUDY PRODUCTS:

(01) Draft automation and robotics options document (Tasks 1, 2, 3).

(02) Draft prioritization document (Tasks 4 and 5) and initial/growth autonomy recommendations (Task 5).

(03) Draft action plus/funding recommendations (Task 6).

(04) Draft growth phasing/scarring recommendations.

(05) Final report.

PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS:

SUBELEMENT NO. & TITLE Undefined Rqmt #

30901 AUTONOMY TECH SELECTION/TIME PHASE -01

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
309M01	AUTONOMY TECH SELECTION/TIME PHASING	07-16-85

	1984			1985								
CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S
FISCAL	FY 85											
MONTH	1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												

STUDY TASKS

A
B
C
D
F
H

1. Identify Autonomy Technologies

(6m/m)

2. Assess Technology Status

Task manning levels assume a 12-person team, with one extra person during Task #4

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
309M01	AUTONOMY TECH SELECTION/TIME PHASING	07-16-85

```
                                      1985      |    1986                    |
                              CALENDAR|O--N--D--|J--F--M--A--M--J--J--A--S|
                                FISCAL|FY 86                               |
                                 MONTH|1  2  3    4  5  6  7  8  9 10 11 12|
                               PHASE B|                                    |
                                     C|                                    |
STUDY  TASKS                          |                                    |
1. (cont)                             |---                                 |
                                      |(6 mm)                              |
                                      |G                                   |
2. (cont)                             |---                                 |
                                      |(12 mm)                             |
3. Determine Initial Station Options  |-----                               |
                                      |(11.5 mm)                           |
                                      |  E                                 |
                                      |  I                                 |
4. Perform Parametric Analyses        |   ----------                       |
                                      |      (6 mm)                        |
5. Prioritize Achieveable Autonomy    |          ------                    |
                                      |           (8 mm)                   |
6. Develop Action Plans and Funding   |      -------------                 |
   Recommendations                    |        (28.5 mm)                   |
                                      |                                    |
7. Develop Growth Timelines and       |            -------                 |
   Scarring Recommendations           |              (15 mm)               |
                                      |                                    |
8. Prepare Final Report               |                   ---------        |
                                      |                     (5 mm)         |
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REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
309M01	AUTONOMY TECH SELECTION/TIME PHASING	07-16-85

SUMMARY SCHEDULE/COST FACTORS

STUDY SPAN: SEP 85-JUL 86 CM = 11

CATEGORY	FACTOR/MM(CM)*	COST $
LABOR		
- NASA Project Mgmt	11 mm	
- Study Mgmt	11 mm	
- Study Tasks		
- Analyst, Eng'g	89 mm	
- Special Skills:		
- Cost Analyst	3 mm	
SPECIAL FACILITIES		
- Computer for Parametric Analyses	3 cm	
TRAVEL		6K
-Team Leader travel to Nasa (assumes -non-NASA leader). Other travel might be -be necessary, depending on consultants -used, whether or not cost model expert -must travel, etc.		
MATERIALS		
TEST PROGRAM		
OTHER (List)		

* MM = Manmonths; CM = Calendar Months

NUMBER	TITLE	DATE
309M02	ON-ORBIT VS. GROUND OFF-NOMINAL ACT. PROTOCOLS	6-24-85

ISSUE #	TITLE	NEED DATE
3090103	ON-ORBIT VS. GROUND OFF-NOMINAL ACT. PROTOCOLS	JUL 87

OBJECTIVES:

(01) Develop off-nominal activities protocols for ground and on-orbit crew activities.

BACKGROUND:

The partition of control of scheduled nominal activities between the ground and on-orbit crews is relatively straightforward because the nominal activities are a defined set of events. This is not the case for off-nominal activities; no matter how many potential anamalous scenarios we generate from our experience, knowledge and informed predictions, new ones will assuredly crop up. This is especially true for such a large, continuous operation as the SSP.

The basic consideration in dealing with off-nominal activities is the difference in status between ground-based and on-orbit personnel. Ground crews have access to a large human resource pool, data base, and computational ability. On-orbit crews have the advantage of proximity to the anomalous event, and real-time interaction with a developing situation.

Some other factors to consider are the degree of autonomy of nominal operations; and also whether the anomaly is associated with "housekeeping" or "experimental" operations. If the latter, control might depend on the experimental design, the level of expertise of the on-board user, and the ability of the on-board database and computational facilities to provide decision-making data.

Another factor is crew sensitivity about ground commands - - its perception of "fate control". This is part of the broader issue of general command authority, which in turn depends on the maturity of the Station, reliability and safety experience, past success in dealing with anomalies, etc.

Thus, developing protocols for off-nominal activities for the SSP requires assessing several types of factors, recognizing past experience, understanding the SSP design and man-machine interfaces, and recognizing the evolutionary nature of on-board confidence.

This document proposes a plan for the construction of such procedures. It's basic inputs are the SSP design and mission sets, and historical experience of manned space missions. The output is recommendations for ground support and on-orbit crew protocols for dealing with off-nominal situations and activities.

INPUTS:

A. SSP SCENARIOS FOR ON-ORBIT ASSEMBLY, EXPERIMENTAL MISSIONS, AND ROUTINE OPERATIONS.
B. VARIOUS STUDIES (E.G., REF. 1) DEALING WITH THE ROLE OF ON-ORBIT PERSONNEL.
C. RECORDS OF OFF-NOMINAL ACTIVITIES OF PREVIOUS MANNED MISSIONS.
D. PREVIOUS GROUND AND ON-ORBIT OFF-NOMINAL ACTIVITIES PROTOCOLS FOR MANNED MISSIONS.
E. RECOMMENDATIONS/REQUIREMENTS FOR INITIAL STATION AUTOMATION (MGMT PLAN 309M01, AUTONOMY TECHNOLOGY SELECTION/TIME PHASING)
F. SSP DESIGN CHARACTERISTICS FROM PHASE B SDR

CRITICAL ASSUMPTIONS:

(01) None

SPECIAL REMARKS:

(01) The need date of July, 1987 is not critical. The time period of this study is geared to take advantage of the SDR design and autonomy recommendations, but still be able to interact, if necessary, with the PDR process. It is recognized that the protocols generated by this effort will be evolving documents, maturing as the program itself matures.

REFERENCES:

(01) The Human Role in Space. MDC H1295, the McDonnell Douglas Astronautic Company, Huntington Beach, CA October 1984. Prepared as DR-4 of NASA contract NAS8-35611.

REPORT FORMAT 14 STUDY PLAN

NUMBER	TITLE	DATE
309M02	ON-ORBIT VS. GROUND OFF-NOMINAL ACT. PROTOCOLS	6-24-85

STUDY TASKS:

(01) Review Relevant Literature - This includes off-nominal protocols and actual events from previous manned space missions.

(02) Assess Previous Experience - Compare protocols with actual off-nominal activities to discover strengths and weaknesses of previous protocols.

(03) Develop SSP Activity Set - Review the SSP design, including autonomy features. From the results of Task 1, develop a representative set of potential off-nominal activities.

(04) Devise Protocols - Using data from Tasks 1, 2, and 3, devise acceptable protocols for ground and on-orbit crews to follow during off-nominal activities.

SPECIAL STUDY NEEDS:

TASK(S)	NEED
1,2	Access to protocols and off-nominal activities for previous manned space missions

SPECIAL SKILLS:

TASK(S)	SKILL
1,2,3,4	Human Factors Engineer

PERFORMING ORGANIZATION:

(01) Managing: NASA-JSC (Level B)

(02) Doing: Aerospace Firms (Prime)
Consulting Firms (Sub)
Universities (Sub)

STUDY PRODUCTS:

Recommended SSP off-nominal activities protocols for ground-based and on-orbit personnel.

Documented rationale in report form.

PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS:

SUBELEMENT NO. & TITLE	Undefined Rqmt #
30901 Station Autonomy - Autonomy	-06b

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
309M02	ON-ORBIT VS. GROUND OFF-NOMINAL ACT. PROTOCOLS	6-24-85

	1986			1987								
CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S
FISCAL	FY 87											
MONTH	1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												
STUDY TASKS												
1. Review Literature				---- (2m/m)	----							
2. Assess Previous Experience				---- (2m/m)	----							
3. Develop SSP Activity Set						---- (2m/m)	----					
4. Devise Protocols								----	---- (3m/m)	----		

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
309M02	ON-ORBIT VS. GROUND OFF-NOMINAL ACT. PROTOCOLS	6-24-85

SUMMARY SCHEDULE/COST FACTORS

STUDY SPAN: JAN 87-AUG 87 CM = 7

CATEGORY	FACTOR/MM(CM)*	COST $
LABOR		
- NASA Project Mgmt	7 mm	
- Study Mgmt	7 mm	
- Study Tasks		
- Analyst, Eng'g		
- Lit. Review	2 mm	
- Assess Experience	2 mm	
- Develop SSP set	2 mm	
- Devise Protocols	3 mm	
- Special Skills:		
SPECIAL FACILITIES		
TRAVEL		6K
3 trips to NASA		
MATERIALS		
TEST PROGRAM		
OTHER (List)		

* MM = Manmonths; CM = Calendar Months

REPORT FORMAT 13 MANAGEMENT PLAN OVERVIEW

NUMBER	TITLE	DATE
309M03	ON-ORBIT VS. GROUND TASK ASSIGNMENT	07-17-85

ISSUE #	TITLE	NEED DATE
3090102	ON-ORBIT VS GROUND TASK ASSIGNMENT	OCT 86

OBJECTIVES:

(01) Establish the time phasing for transferring Space Station tasks from the ground to the station.

BACKGROUND:

Because of the length of service life projected for the Space Station and the varied missions expected, the degree of ground control involvement in Space Station operations is expected to change over time. Initially, there will be substantial ground mission operations control. As the system matures and confidence in autonomous systems increases, there will be a transition from intensive ground control to more on-orbit control.

Time phasing of the transition of tasks from the ground to the on-orbit crew must be established to afford the most efficient transferring of responsibility. This issue resolution study will define this task assignment transition plan.

INPUTS:

A. Crew tasks identified in WP-01, -02, -03, and -04
B. Time phasing for implementation of autonomy technologies from Management Plan 309M01 - AUTONOMY TECHNOLOGIES/TIME PHASING

CRITICAL ASSUMPTIONS:

(01) Space Station flight operations will become more autonomous over time.

(02) This study will be conducted in parallel with the Managment Plan 309M01 study.

SPECIAL REMARKS:

(01) The time phasing of transferring task responsibility from the ground to the flight crew will be paced by the time phasing of implementation of autonomy technologies. The plan for the implementation of autonomy technologies is to be determined in Management Plan 309M01. Therefore, this study has been coordinated with the schedule for Management Plan 309M01.

REFERENCES:

(01) None

REPORT FORMAT 14 STUDY PLAN

NUMBER	TITLE	DATE
309M03	ON-ORBIT VS. GROUND TASK ASSIGNMENT	07-17-85

STUDY TASKS:

(01) Define Preliminary IOC Flight and Ground Crew Tasks - Collect and integrate preliminary flight and ground crew task data which will be generated by the WP-01, -02, -03, and -04 Phase B contractors. This integrated task assignment listing will become the baseline on which the time-phasing of crew task assignment will be based.

(02) Define Crew Tasks Associated with Autonomy Technology Options - Review the autonomy technology time-phasing options generated by tasks of Management Plan 309M01. Define the ground and flight crew tasks that will be associated with each technology option. Assess the workload implications on both the ground and flight crews. Provide crew impact data to the trade studies to be conducted in Task 4 of Management Plan 309M01. Obtain results of trade studies and define crew tasks associated with the selected autonomy installation plan.

(03) Define the Time-Phased Flight vs Ground Crew Task Assignments - Using the results of Task 2 and the updated flight and ground crew task data which will be generated by the WP-01, -02, -03, and -04 Phase B contractors, define the time-phasing of the ground tasks becoming on-orbit tasks and vice versa.

SPECIAL STUDY NEEDS:

TASK(S)	NEED
1,3	Availability of ground and flight crew task data from WP-01, -02, -03, and -04.

SPECIAL SKILLS:

TASK(S)	SKILL
1,2,3	Human Engineering Analyst

PERFORMING ORGANIZATION:

(01) Managing: NASA/JSC Level B

(02) Doing: Aerospace Contractor

STUDY PRODUCTS:

Detailed time-phased specifications for the assignment of Space Station tasks to ground and flight crews.

PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS:

SUBELEMENT NO. & TITLE		Undefined Rqmt #
30901	AUTONOMY	-05a
30603	SCHEDULING METHODS	-02

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
309M03	ON-ORBIT VS. GROUND TASK ASSIGNMENT	07-17-85

	1985			1986								
CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S
FISCAL MONTH	FY 86 1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												
STUDY TASKS												
1. Define Prelim. IOC Flight vs Ground Crew Task Assignments	A ------ (4 mm)	------										
2. Define Crew Tasks Associated With Autonomy Technology Options		------	------ (6 mm)	------								
3. Define Time-Phased Flight vs Ground Crew Task Assignments					B ------	------	------	------ (10 mm)	------	------	------	------

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
309M03	ON-ORBIT VS. GROUND TASK ASSIGNMENT	07-17-85

SUMMARY SCHEDULE/COST FACTORS

STUDY SPAN: OCT 85-SEP 86 CM = 12

CATEGORY	FACTOR/MM(CM)*	COST $
LABOR		
- NASA Project Mgmt	6 mm	
- Study Mgmt	12 mm	
- Study Tasks		
- Analyst, Eng'g	20 mm	
- Special Skills:		

SPECIAL FACILITIES

TRAVEL

MATERIALS

TEST PROGRAM

OTHER (List)

* MM = Manmonths; CM = Calendar Months

REPORT FORMAT 13 MANAGEMENT PLAN OVERVIEW

NUMBER	TITLE	DATE
401M01	WORKSTATION DESIGN GUIDELINES	7-19-85

ISSUE #	TITLE	NEED DATE
4010201	WORKSTATION DESIGN GUIDELINES	FEB 87

OBJECTIVES:

(01) To develop workstation man/system integration standards, requirements, and guidelines for all Space Station workstations.

BACKGROUND

It is essential that a consistant set of human engineering design guidelines be developed for the design of the Space Station workstations in order to increase the crew's efficiency and to minimize the potential for human error when using the workstations. These guidelines include specification of console configuration, restraints, writing surfaces, controls, displays, labeling, etc. The determined requirements will have significant impact on cost, weight, volume, and layout for the interior configuration of the station.

There are currently several human engineering standards which must be drawn upon when designing new space hardware: 1) MIL-STD-1472C, Human Engineering Standards for Military Systems; 2) MSFC-STD-512A, Man/System Requirements for Weightless Environments, 3) SC-E-0006, General Specifications, Manned Spaceflight EVA Support Equipment, Function Design Requirements, and 4) JSC-07387B, Crew Station Specifications. The first one is for terrestrial systems and the latter ones are out of date. It is essential that an up-to-date integrated space human engineering standards document be produced to facilitate the Space Station Phase B/C/D design and other future space systems which will require in-space manned interaction.

The Man-System Integration, Standards, Requirements, and Guidelines program (JSC RFP-9BE3-6-5-45P) includes the development of workstation human engineering design standards. This effort will completely satisfy the issues and objectives stated in this management plan, therefore, no further effort is proposed.

INPUTS:

A. Existing Human Engineering Standards
B. Human Factors data
C. Space manned systems experience data
D. NASA standards protocols
E. TASK VERIFICATION REQUIREMENTS (possible requirement for dual operators at same workstations), Management Plan 401M02.

CRITICAL ASSUMPTIONS:

(01) The Man/Systems Integrations Standards program will be implemented for completion by February 1987 and will entirely resolve Issue 4010201.

SPECIAL REMARKS:

(01) The results of the Man/Systems Integration Standards program will resolve the undefined requirements in Subelement 40102 - Workstation General Requirements.

REFERENCES:

(01) None

REPORT FORMAT 13 MANAGEMENT PLAN OVERVIEW

NUMBER	TITLE	DATE
401M02	TASK VERIFICATION AT WORKSTATIONS	7-19-85

ISSUE #	TITLE	NEED DATE
4010202	TASK VERIFICATION AT WORKSTATIONS	JUL 86

OBJECTIVES:

(01) Determine the configuration, cost, volume and mass impacts on workstation design and development to provide for 2 crewmember occupancy to facilitate QA task verification.

BACKGROUND:

Simplicity and cost considerations appear to dictate that the Space Station IVA workstations be designed around a requirement for a single operator (see Reference 1a). On the other hand, the quality assurance doctrine of independent observation and verification of critical procedures (see Reference 1b) may require that workstations be designed to accommodate 2 crewpersons.

These apparently conflicting requirements will be resolved through performance of two studies:

o An analysis to define the cost, weight and volume penalties inherent in designing workstations for 2 crewmember occupancy to facilitate task verification; and

o A trade study of the generic necessity for process verification vs. design penalties (see Reference 2).

This management plan outlines the first of the above two studies. It describes the effort required to assess the impact of designing Space Station workstations with two-person presence for task verification purposes. The output of this study will serve two ends. First, it will provide a necessary input for the second study described above, which will include final requirements and recommendations, and second, it will provide an option to the workstation preliminary design process being conducted as part of the SSP Phase B effort.

INPUTS:

A. SSP workstation design concepts from WP-01, 02, and 03 contractors.

CRITICAL ASSUMPTIONS:

(01) QA task verification by an independent observer will be a requirement for the SSP. (Management Plan 218M05, Quality Assurance On-Orbit Verification Requirements, will analyze the validity of this requirement).

SPECIAL REMARKS:

(01) This study must be performed in a parallel with the first part of the study described in Reference 2. The need date of July 1986 is based on this study's results being used as an input as described above.

(02) It is possible that these results will demonstrate a negligible impact on workstation design and development. In such a case, the need date will provide lead time to incorporate dual occupancy workstation requirements into the preliminary design effort ongoing in SSP Phase B.

(03) This study should interact with Management Plan 216M01 - RESTRAINTS.

REFERENCES:

(01 Space Station Human Productivity Requirements Document, (NASA document number to be assigned), NASA-JSC, (Release date TBD).
a. Subelement 40102, Requirement No. -02
b. Subelement 21801, Requirement No. -02c

(02) Management Plan 218M05, QA On-orbit Verification Requirements. (This plan will be resolved by Space Station Program Operations Plan (POP) 488-40 Task 1, "Develop On-orbit Quality Assurance Verification Methods/Techniques").

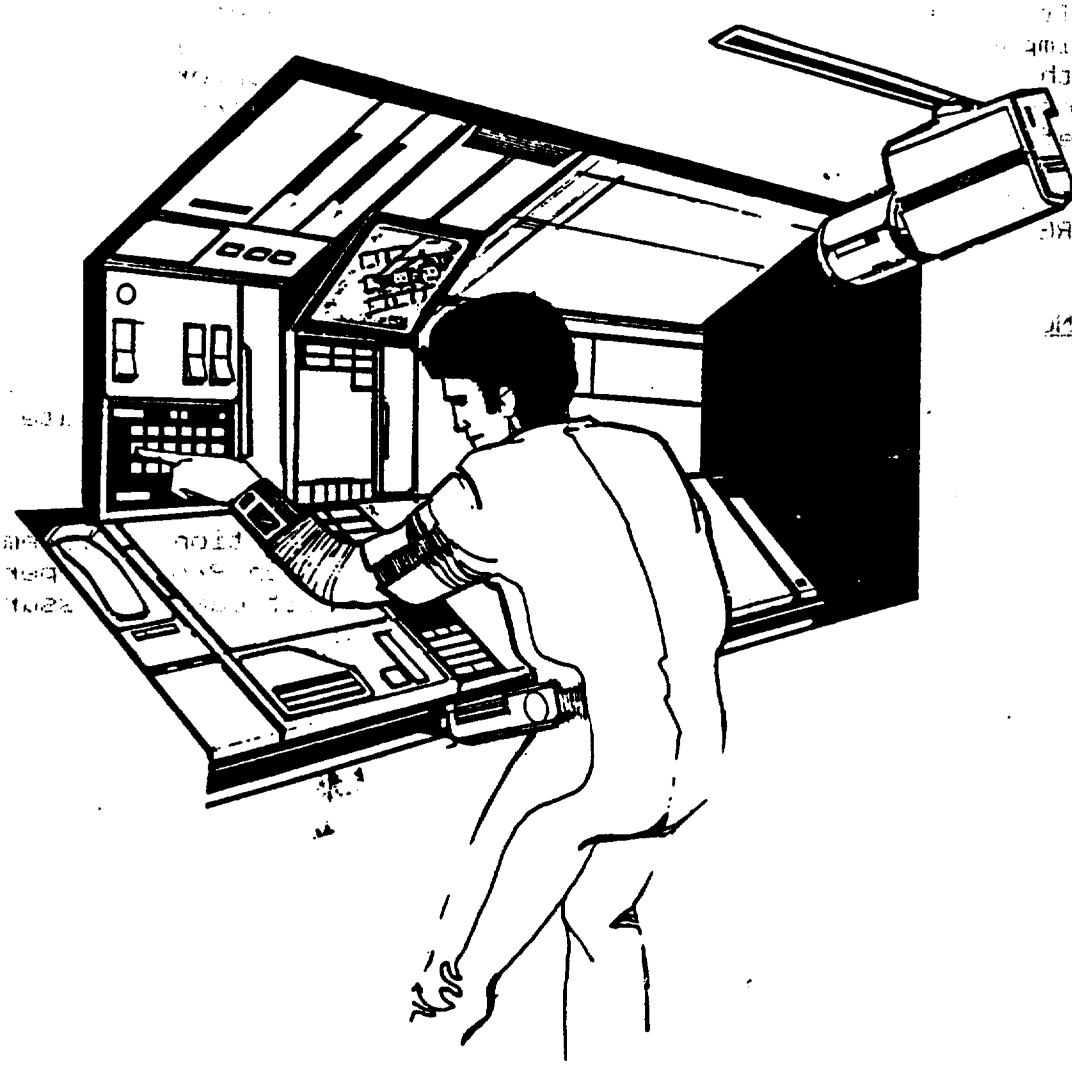

Figure 1. (Management Plan 401M02) Task verification through the use of closed circuit TV(CCTV).

REPORT FORMAT 14 STUDY PLAN

NUMBER	TITLE	DATE
401M02	TASK VERIFICATION AT WORKSTATIONS	7-19-85

STUDY TASKS:

(01) Workstation Design Impact Study - Examine current workstation designs which use single operator concepts and assess changes necessary to accommodate a second task-verification observer. Quantify the impact of those changes with respect to configuration,weight, volume, complexity and cost.

SPECIAL STUDY NEEDS:

TASK(S)	NEED
	None

SPECIAL SKILLS:

TASK(S)	SKILL
1	Crew Systems Analyst

PERFORMING ORGANIZATION:

(01) Managing: NASA/MSFC - WP01

(02) Doing: Aerospace Firms, WP01

STUDY PRODUCTS:

Report on the design and development impact of accommodating a second operator for task verification capability at Space Station workstations. This data will be a critical input to Management Plan 218M05 (Ref. 2) where the trade study will be performed to determine if the verifiction should be accomplished via a second observer at the workstation or via some other means.

PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS:

SUBELEMENT NO. & TITLE	Undefined Rqmt #
21801 QA ON-ORBIT VERIFICATION PROCEDURES	-02c

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
401M02	TASK VERIFICATION AT WORKSTATIONS	7-19-85

	1985			1986								
CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S
FISCAL	FY 86											
MONTH	1	2	3	4	5	6	7	8	9	10	11	12
PHASE B												
C												
STUDY TASKS												
Assumes SRR Mar 7-21, 1986												
1. Workstation Design Impact Study								2 mm				

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER	TITLE	DATE
401M02	TASK VERIFICATION AT WORKSTATIONS	7-19-85

SUMMARY SCHEDULE/COST FACTORS

STUDY SPAN: MAY 86-JUN 86 CM = 2

CATEGORY	FACTOR/MM(CM)*	COST $
LABOR		
- NASA Project Mgmt	0.2 mm	
- Study Mgmt	0.2 mm	
- Study Tasks		
- Analyst, Eng'g	2 mm	
- Special Skills:		
SPECIAL FACILITIES		
TRAVEL		
- Two trips to NASA by performing individuals. Assumes study is contracted.		2 K
MATERIALS		
TEST PROGRAM		
OTHER (List)		

* MM = Manmonths; CM = Calendar Months